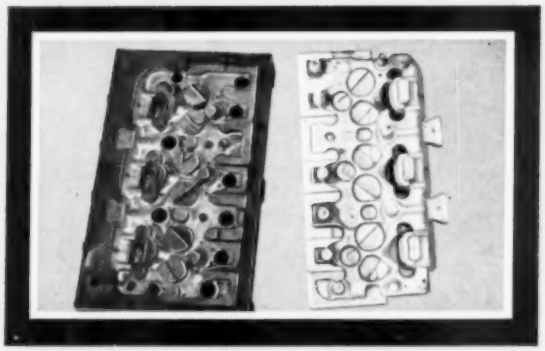
THE SOCIETY OF

PLASTICS ENGINEERS JOURNAL

EPON® RESIN does it!

Speeds up International Harvester's Milwaukee Works' pattern modifications 65% ...cuts costs 50%!



Minimizes costs of design changes—International Harvester saved $2000 by making design modifications on an Epon resin model (right) of original drag jacket corebox (left).

Both model and mold are produced from an Epon resin-glass cloth laminate made for International Harvester's Milwaukee Works by Kish Industries, Inc., Lansing, Michigan.

Epon Resin simplifies pattern production—Epon resin faced cope and drag patterns for an IH engine can be drawn from molds with little danger of sticking.

Here's how:

At INTERNATIONAL HARVESTER CO., world-famous manufacturers of farm equipment, Epon resins have created a money-saving revolution in foundry pattern modification.

For example: to enlarge the cross section of a frame casting for an IH crawler tractor, a pattern change would normally require 3 weeks and cost $700. *But by applying Epon resin . . . costs dropped to $300 . . . and the pattern was back in production in 1 week!*

In another situation, the use of Epon resin to make a plastic core model of a new drag jacket corebox from the old one saved IH over $2000.

In many fields of industry, the Epon resins are making such savings possible because they have ideal properties for tooling applications:

- Exceptional dimensional stability . . . high impact strength . . . excellent resistance to abrasion . . . minimum residual stress in cured parts.
- Ease and speed of preparation.
- Low shrinkage in filled formulations, assuring perfect master reproductions; minimum warping and stresses.
- Adaptability to repairs and design changes.
- Minimum finishing requirements for smooth surfaces.

Can Epon resin tools and dies make comparable improvements and savings in *your* operations? Find out now by writing your tooling resin formulator.

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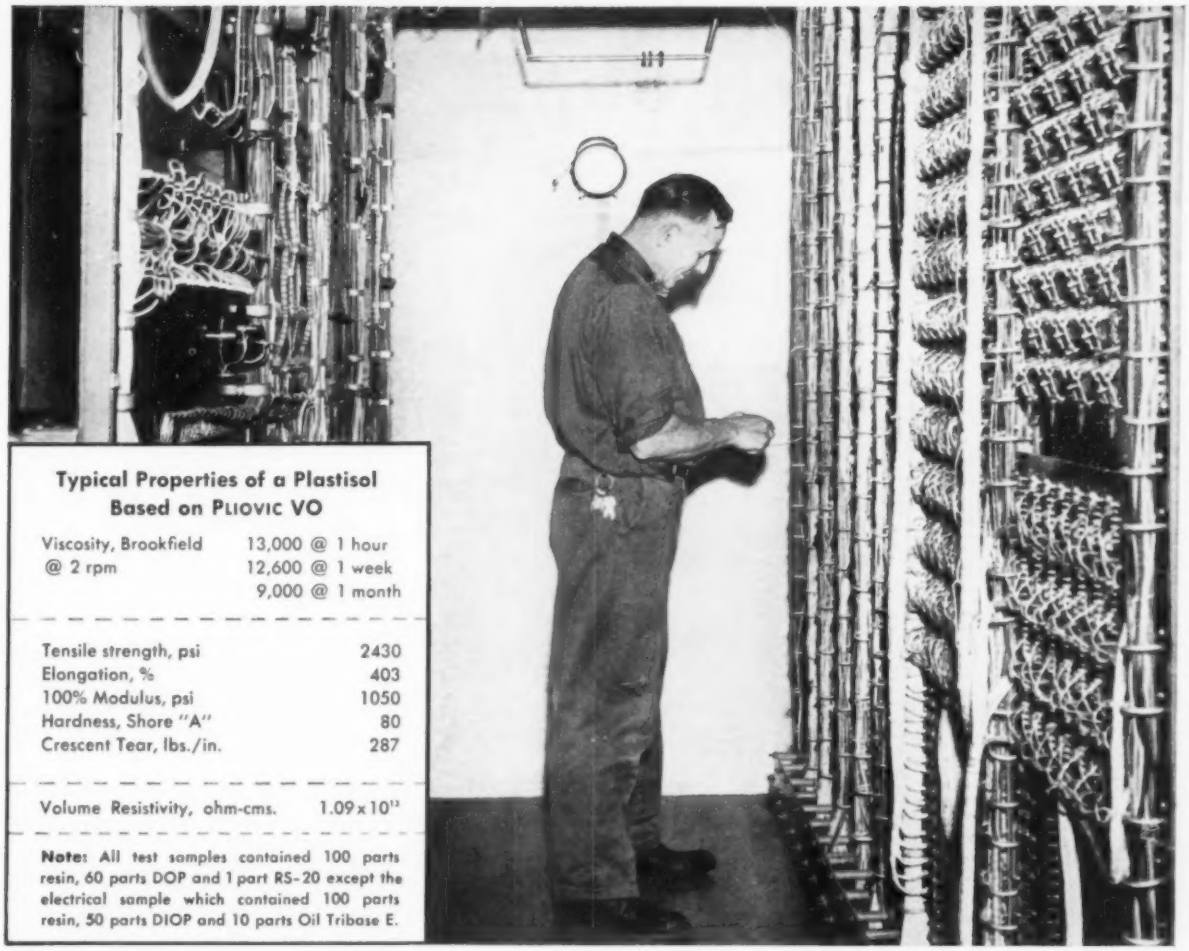

Typical Properties of a Plastisol Based on PLIOVIC VO

Viscosity, Brookfield @ 2 rpm	13,000 @ 1 hour 12,600 @ 1 week 9,000 @ 1 month
Tensile strength, psi	2430
Elongation, %	403
100% Modulus, psi	1050
Hardness, Shore "A"	80
Crescent Tear, lbs./in.	287
Volume Resistivity, ohm-cms.	1.09×10^{13}

Note: All test samples contained 100 parts resin, 60 parts DOP and 1 part RS-20 except the electrical sample which contained 100 parts resin, 50 parts DIOP and 10 parts Oil Tribase E.

New—and purely superior!

If you're looking for something new and different in dispersion resins, particularly for use in electrical applications, you can stop right now. For in new PLIOVIC VO, we have just that.

PLIOVIC VO is a straight polyvinyl chloride resin of exceptional purity. It is designed and made for use in plastisols and organosols for electrical applications, for rotational and slush molding, for metal coatings and for dip coatings.

Compounds based on PLIOVIC VO exhibit the following characteristics: 1. Extremely low initial viscosity. 2. Outstanding shelf stability. 3. Superior electrical properties. 4. Excellent heat stability. 5. Good physical properties. 6. Exceptionally low water absorption. 7. Good film clarity.

Plastisols made with PLIOVIC VO are effectively protected against heat and light with small amounts of economical zinc-type stabilizers. They also are readily deaerated to assure uniform cross sections. And they exhibit a very desirable, dry, nongreasy feel. For full details, including the latest *Tech Book Bulletins*, on the new PLIOVIC VO, the unique PLIOVIC AO, or their blends, just write to: Goodyear, Chemical Division, Akron 16, Ohio.

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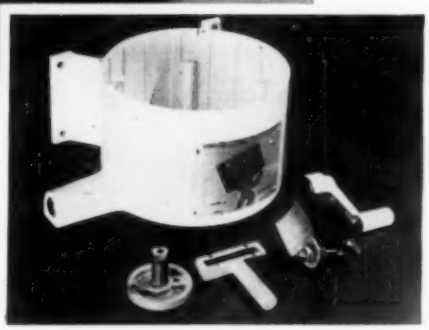
Another new development using

B.F.Goodrich Chemical *raw materials*

Soap dispenser housing, crank, plunger, plug and dish are polyvinyl compound molded of rigid Geon by Tube Turns Plastics, Inc., Louisville, Kentucky, for Sugar Beet Products Company, Saginaw, Michigan. Rigid Geon compounds are supplied by B.F.Goodrich Chemical Co.



rigid Geon vinyl makes it rugged, rust-proof and attractive

For good looks, durability and cost savings, too, these soap dispensers for plant and office washrooms are made of high impact rigid Geon vinyl.

These dispensers are durable—they resist breakage—and they won't rust, corrode or react chemically with the soaps they dispense. Total cost is less, since no finishing or painting is required, and colors can be molded in the material.

Rigid Geon is also used for piping, fittings, and extruded shapes. Foam Geon makes cushions and safety padding. Protective coatings for steel, paper, upholstery and flexible wire insulation, too, are made from versatile Geon polyvinyl materials.

For technical information on Geon, write Dept. MG-1, B. F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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SPE JOURNAL

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Calendar of SPE Technical Meetings

CHICAGO RETEC

"New Developments in Injection Molding Techniques"
April 18, 1958 **Conrad Hilton Hotel**

Write for further information to the Retec Chairman, John Adams, Eastman Chemical Products, Inc., 4200 Dempster St., Skokie, Illinois.

WESTERN NEW ENGLAND RETEC

"Plastics In Packaging"
October 1, 1958 **Statler Hotel, Hartford, Conn.**

Write for further information to the Retec Chairman, Blakley McNeil, Fuller Brush Company, 3580 Main Street, Hartford, Conn.

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Yield (p.s.i.)	D638-52T	3380–5020
Break (p.s.i.)	D638-52T	3470–5240
Elongation (%)	D638-52T	56–66
Flexural properties:		
Flexural strength (p.s.i. at break)	D790-49T	6400–8500
Flexural modulus (10^5 p.s.i.)	D790-49T	0.23–0.30
Rockwell hardness: (R scale)	D785-51	62–94
Izod impact: (ft. lb./in. notch)	D256-43T	2.7–11.0
Heat distortion: (°C.)	D648-45T	59–70
Water absorption:		
% sol. lost	D570-42	0.00–0.08
% moisture gain	D570-42	1.5–1.8
% water absorption	D570-42	1.6–1.8

Celanese Corporation of America, Plastics Division
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Vol. III No. 1

POLYETHYLENE PROCESSING TIPS

PROCESSING CONDITIONS AFFECT STRESS-CRACK RESISTANCE OF POLYETHYLENE PRODUCTS

Most thermoplastic materials are subject in varying degrees to environmental stress-cracking . . . and polyethylene is no exception. Stress-crack failures may occur in polyethylene when the plastic is under high local stresses, either externally or internally applied, and in contact with soap, detergent or solvent.

Stress crack resistance depends on the resin used, and the processing conditions. The effect of polyethylene resin properties were discussed in the last issue of TIPS. This issue will be devoted to the effect of processing conditions.

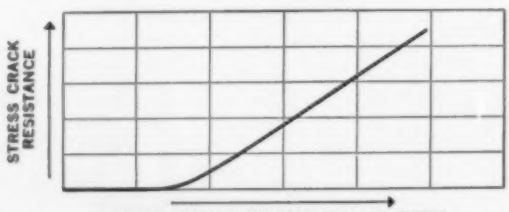
Apart from outside forces, there are, for a given polyethylene resin, two main causes of stress-cracking: locked-in stresses, and a high degree of molecular orientation. Locked-in stresses arise from uneven shrinkage during cooling. In molecular orientation, polyethylene molecules are comparable to iron filings in a magnetic field; they line up in force or stress patterns which, in effect, are stress concentrations along which fractures may occur.

Mold design affects stress cracking

To improve the stress-crack resistance of molded polyethylene, the molder should select his resin carefully on the basis of mold design, injection and mold temperatures, and, of course, the properties he wants in his end product.

Here, for example, is one way in which mold design can influence the choice of a resin: It is *generally* true that resins of higher molecular weight have relatively high stress-crack resistance. But in deep-draw molded items, or those with large cross-sections, resins of low molecular weight often yield a product with better stress-crack properties. This is because resins of low molecular weight—and hence, lower viscosity—permit the mold to fill more quickly. Under these conditions the material cools at a more uniform rate and fewer internal stresses are created.

Different flow rates, due to abrupt changes in mold cross-section or to sharp corners, may create points of stress concentration. These cannot always be eliminated, since every design is a compromise between mold engineering and product design.

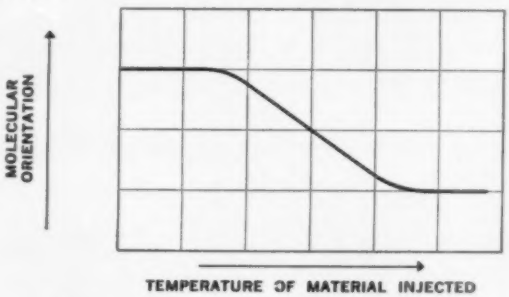


Stress crack resistance increases with higher stock temperatures in injection molding.

How Cold the Mold?

Higher production rates, made possible by running a cold mold, may be offset by a high incidence of stress-crack failures due to molecular orientation. This difficulty may be minimized by using a resin with the right flow properties—always bearing in mind that a practical compromise must be made with other desired end properties. Molecular orientation occurs when the hot resin comes in contact with the relatively cool walls of the mold. The outer surface of the stream cools faster than the interior and tends to slow down, while the material nearer the center flows unimpeded. The molecules tend to line up in the direction of flow.

This difference in cooling rates between the material at the periphery of the stream and its center also sets up internal stresses which induce stress-crack failures.



Molecular orientation is decreased with higher stock temperatures.

Mold Release Agents have some effect

Mold release agents may be of some benefit, as they tend to reduce the "drag" effect. However, caution must be used in their selection, since certain materials may induce stress cracking.

Compromise is often necessary

While no simple answer exists to the problem of stress-cracking in polyethylene products, resistance can usually be brought to a satisfactory level by choosing the best resin, making adjustments in molding temperatures, cooling rates and mold design. Since certain compromises must always be made, in selecting a resin and in processing techniques, processors can frequently use the services of a resin specialist. U.S.I.'s Technical Service Engineers are ready to discuss your processing problems, and to help in every way to solve them.

U.S.I. INDUSTRIAL CHEMICALS CO.
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National SPE Officers for 1958

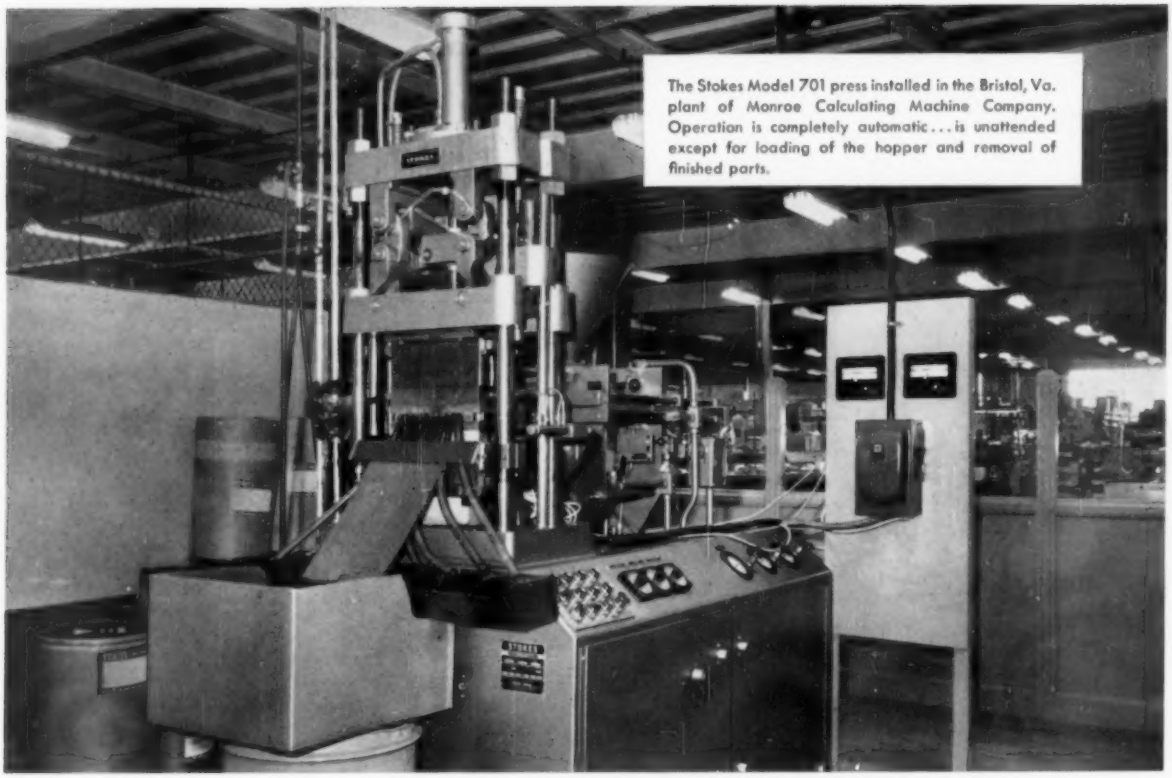
New National Officers elected at the Fourteenth Antec, held in Detroit, January 27th were R. K. Gossett, President; Frederick C. Sutro, Jr., Vice-President; George W. Martin, Secretary; and G. Palmer Humphrey, Treasurer.

R. Kenneth Gossett has been since 1946 the President of Gossett and Hill Co., Chicago. He joined SPE in 1947 and has served in the following capacities: Co-chairman 1952 Antec, President Chicago Section 1955, National Director from Chicago 1956-57, Chairman of National Meetings Committee, 1956, National Secretary 1957. He earned his degree in Mechanical Engineering at Purdue in 1942. He is married and has three children.

George W. Martin is President and General Manager of Holyoke Plastics Corp., Holyoke, Mass. He joined SPE in 1947 and served as local section secretary in 1952 and 1953 and as section president in 1954 of Western New England. He served as national director since 1956, and on the executive committee and as administrator of the Professional Activity Groups in 1957. He is married and has four children.

Frederick Charles Sutro, Jr., is Product Manager, Polyethylene for Spencer Chemical Co., Kansas City, Missouri. He graduated from Yale in Industrial Administration in 1943 and served in the Army Air Force as second lieutenant in 1943-44. He joined Spencer in 1954, after ten years of experience with Bakelite and P.M. Industries. He joined SPE in 1946 and is a charter member of both the New York and Kansas City Sections. He has been on the National Council since 1955.

G. Palmer Humphrey is Vice President of R.C. Molding at New Hyde Park, Long Island. He entered the plastics industry in 1943 and joined R.C. Molding in 1952. He has held all offices in the New York Section and served as National Councilman. He is chairman of the Membership Committee, and Treasurer for the 15th Antec. He lives in Roslyn, N.Y., is married and has three sons.



The Stokes Model 701 press installed in the Bristol, Va. plant of Monroe Calculating Machine Company. Operation is completely automatic... is unattended except for loading of the hopper and removal of finished parts.

Monroe Calculating Company saves with Stokes 701 automatic injection press

Monroe Calculating Machine Company, world famous for its quality machines and progressive engineering outlook, is ever on the alert for new, more advanced manufacturing methods. It discovered, in the Stokes 701, an improved and more economical method for molding numerical inserts for keyboard buttons.

The Company automatically molds and sorts the inserts . . . 9-at-a-time . . . at its Bristol, Va., plant. The Stokes 701 automatic injection machine operates virtually unattended . . . has provided a 13% increase in production, and has reduced man-hours by over 85%. As a result of this experience, Monroe has purchased 2 additional Stokes 701's...one for its Orange, N.J., plant, the other for Monroe-Holland in Amsterdam.

The Stokes Model 701 machine often economically replaces 4-ounce or larger machines since freedom from the labor factor allows the number of cavities in the die to be planned for optimum production requirements. It does not require special attachments or extra-cost gimmicks. The automatic features are integral. Its precisely repeated automatic cycles provide a higher degree of uniformity and quality of finished parts. The patented Stokes ejection system positively clears all parts and runners from the die. Secondary protection is provided by the use of the more common low-pressure close. The completely self-contained vertical design of the Stokes 701 saves floor space . . . permits easy attendance . . . and facilitates mold set-up.

Write for your copy of literature on the Stokes Model 701—the truly automatic 2-ounce injection molding press. Ask for a Stokes production analysis on your own parts.

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New Sales Service Lab at Bartlesville is completely equipped with latest commercial processing machinery and research apparatus. Phillips experienced technical service staff will assist you in developing new products and processes using MARLEX plastics. Please make arrangements through your local MARLEX sales representative. Meanwhile, for complete data on MARLEX 50, send for our latest illustrated technical brochure.

Ease of extrusion, low permeability, chemical resistance and rigidity of MARLEX 50 plastic make it ideal for blow molding many types of food and drug bottles, squeeze bottles and aerosols. Its stiffness permits reductions in wall thickness with consequent savings of resin. Conventional processing techniques produce high-quality blown products with glossy surfaces and minimum internal stress.

Toys and housewares are a natural for this unbreakable, heat-resistant, nontoxic material. Its high tensile and impact strength and lack of brittleness at extremely low temperatures suggest many new applications unsuited to conventional polyethylenes. Molders can profit from the fact that form stability at higher temperatures frequently permits quicker mold ejection and shorter cycle times.

*MARLEX is a trademark for Phillips family of olefin polymers.

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How STANDARD takes an idea

. . . and makes molds for a vending machine

THE CASE HISTORY OF A GUM BALL DISPENSER

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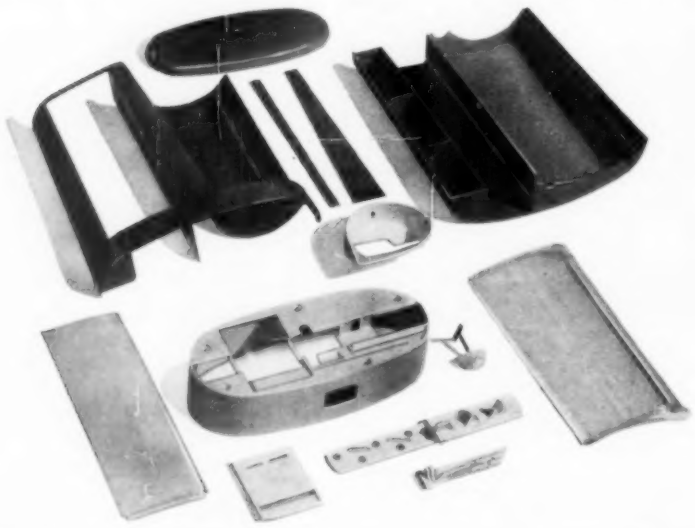
EAST BOSTON, MASS.

Here's a brief account of a typical problem recently solved by our engineers and designers . . . from idea to finished product.

The problem — to design for plastics fabrication a low cost, attractive gum ball dispenser for store counters. The machine was to be molded of high impact plastic in brilliant colors and components had to be kept to a minimum to reduce handling and assembly costs.

Our answer is the finished product shown on this page. This is evidence of Standard's ability to meet the most challenging problems in the plastics industry and come up with the answers. Our team of engineers backed by skilled mold makers in one of the most modern plants in the country offer their skill and the experience of forty-seven years in the plastic industry.

Six well designed molds produce these 13 parts



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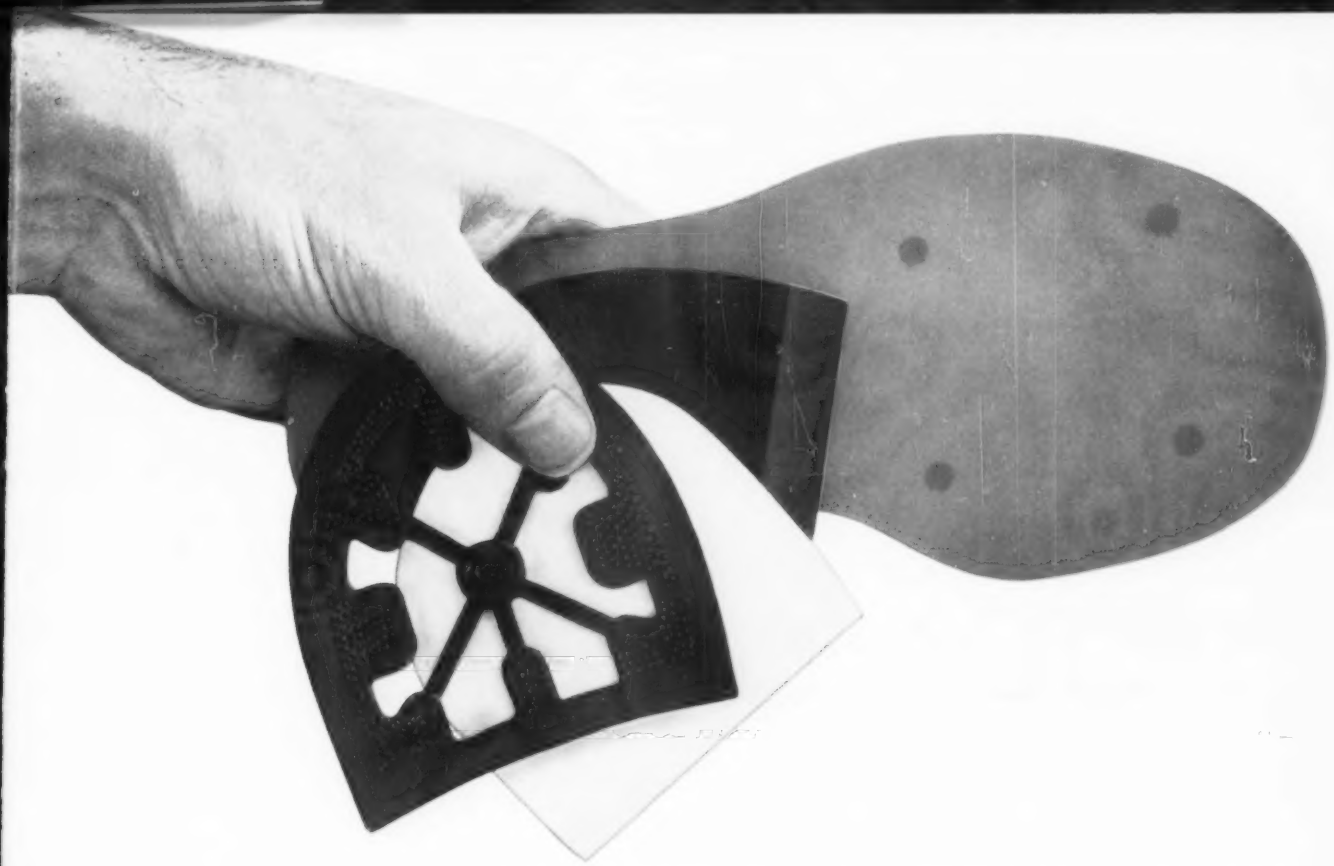


Shoe parts of **TENITE POLYETHYLENE**

offer better flexibility
easier workability
improved moisture resistance
longer life

Plastics are becoming more important every day in shoe construction. The midsole, Dutchman heel pieces, and heel base shown above, for example, illustrate new uses of Tenite Polyethylene by Endicott-Johnson Corporation, a leading name in the shoe industry.

Tenite Polyethylene is a plastic with properties useful to shoe manufacturers. It is light in weight and resists chemical attack, aging and moisture. It is easy to form; parts can be molded, or cut from extruded sheet. It can be supplied in colors.

Endicott-Johnson cite numerous benefits from their use of Tenite Polyethylene. Dutchman heel pieces, they report, formerly were made of fibre and leather. By using Tenite Polyethylene, they now have a material more adaptable to rounding and skiving, which permits production of better-fitting shoes. The new heel pieces also have greater flexibility and moisture resistance—two important considerations for any heel piece.

Their heel bases formerly were made of rubber. By switching to plastic, Endicott-Johnson feel that their new bases are more serviceable and that quality control has been made more precise.

Midsoles formerly were made of leather. Here again, the change to polyethylene has meant improvements in workability, flexibility and moisture resistance.

Today, many industries are using Tenite Polyethylene in place of traditional materials. Perhaps you, too, have a product that could be given improved performance or longer life if made of this versatile plastic. For more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

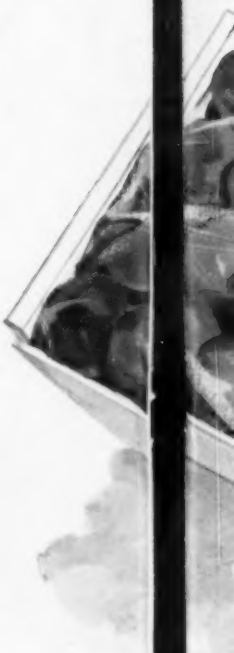
TENITE
POLYETHYLENE
an Eastman plastic

Announcing... *Monsanto's improved film resin for industrial packaging and barrier uses*

MONSANTO POLYETHYLENE 706

Monsanto Polyethylene 706 resin has been developed specifically for industrial packaging and barrier uses. An unmodified resin containing no additives, 706 meets the most exacting requirements for industrial film applications regardless of the fabricated product—from toughness and uniformity of appearance to ease of handling on fabricating machines and openability. This outstanding new resin is chemically inert and possesses carefully controlled physical properties.

Already performing for many important film extruders, this newest in the expanding Monsanto Polyethylene resin series is now available in full commercial quantities. For complete data, and other information, write Monsanto Chemical Company, Plastics Division, Room 1771, Springfield 2, Mass.



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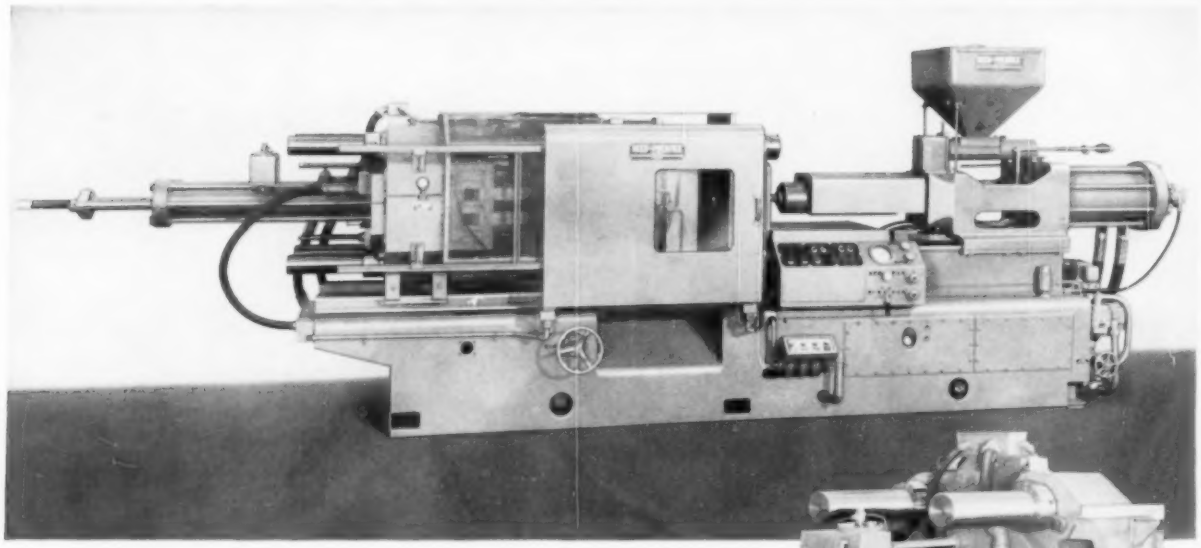

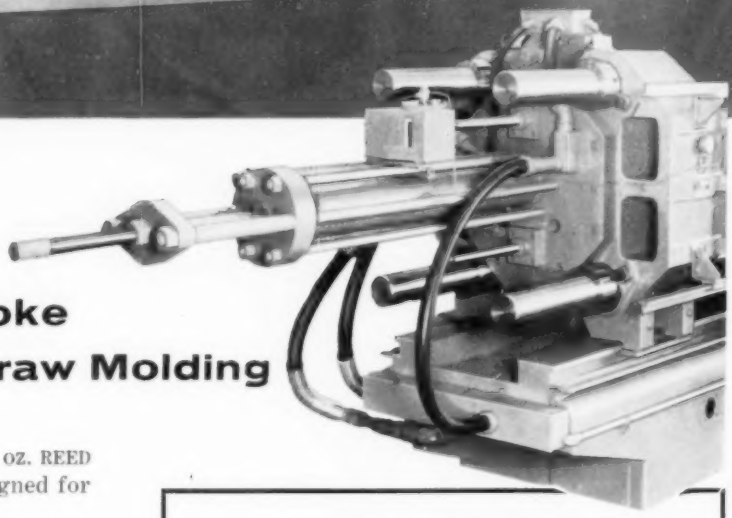

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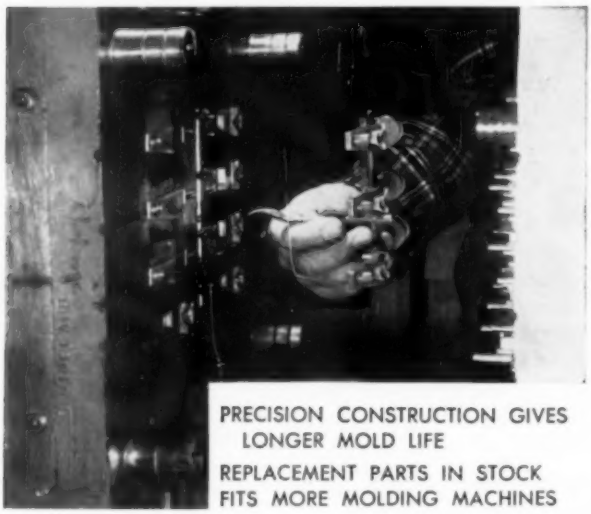

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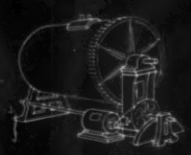

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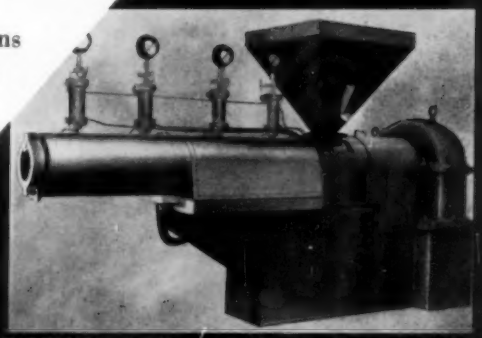

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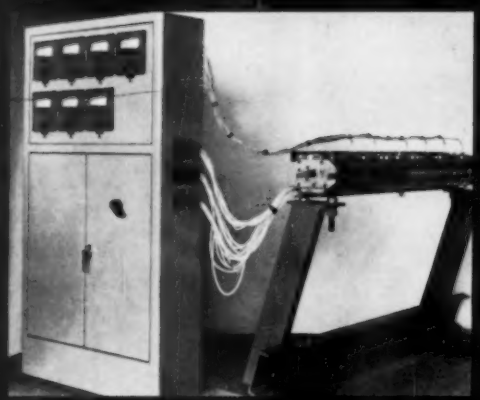

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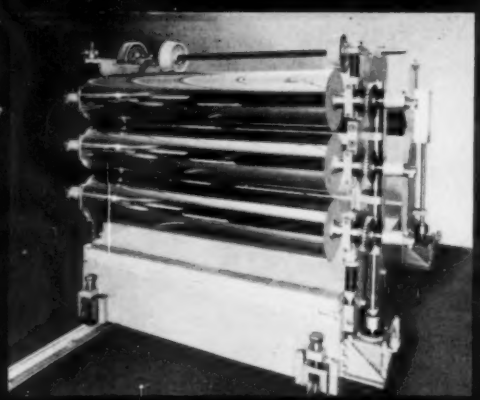

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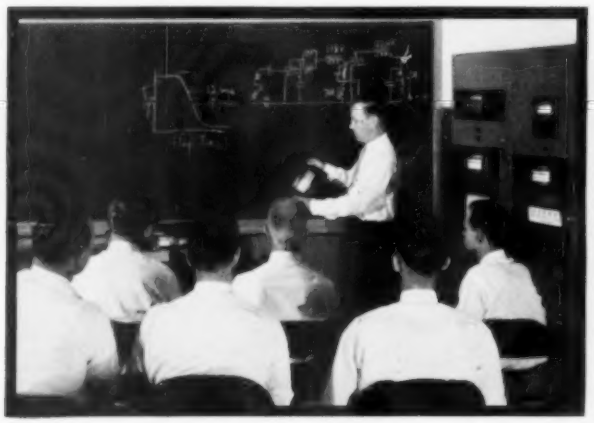

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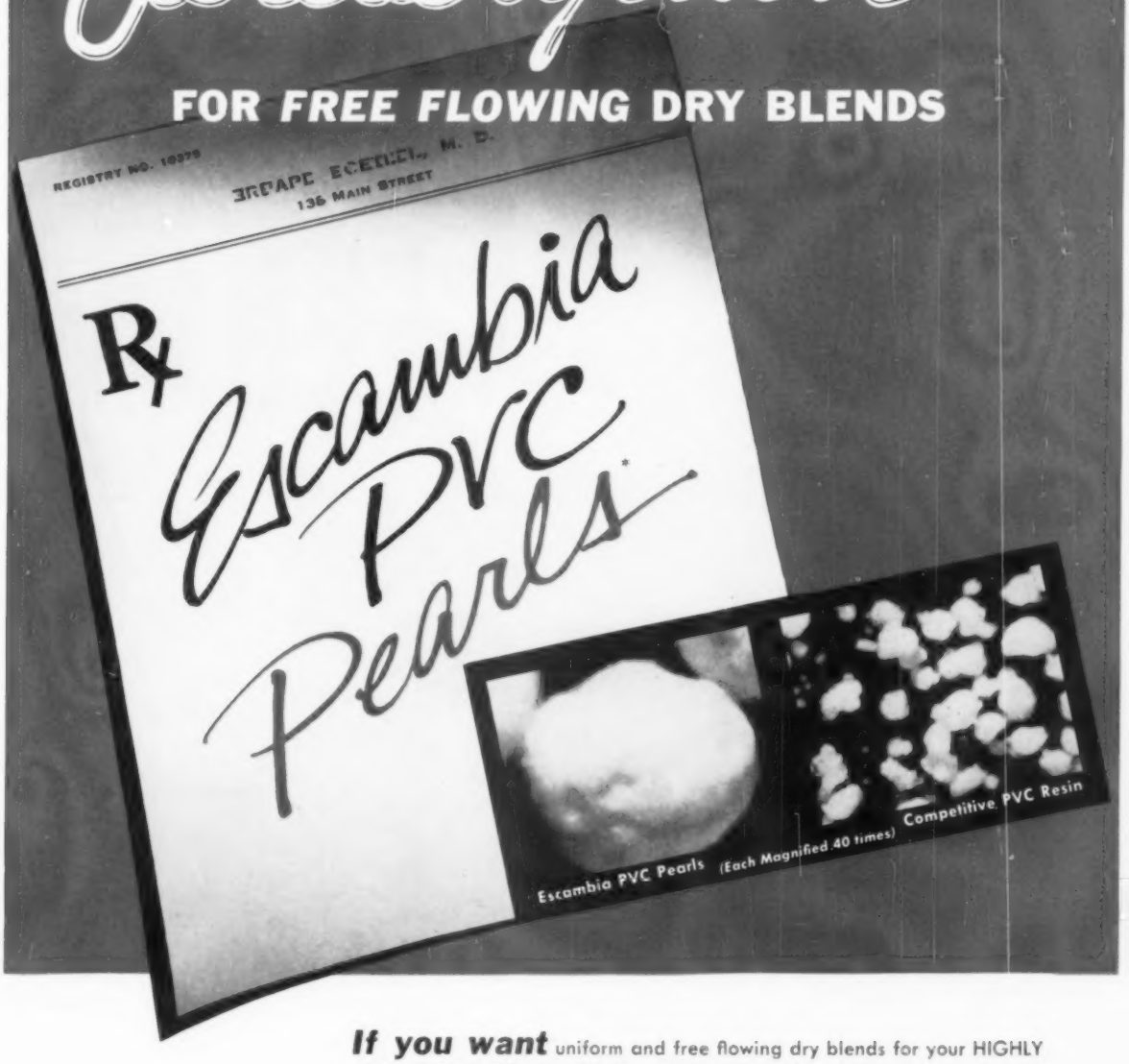

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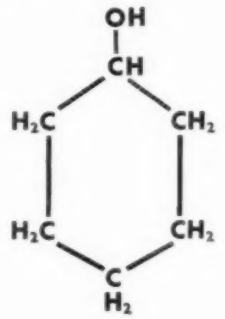

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PLASTICS ENGINEERS JOURNAL

Volume 14, Number 2 • February, 1958

CONICAL HEAT CHAMBERS

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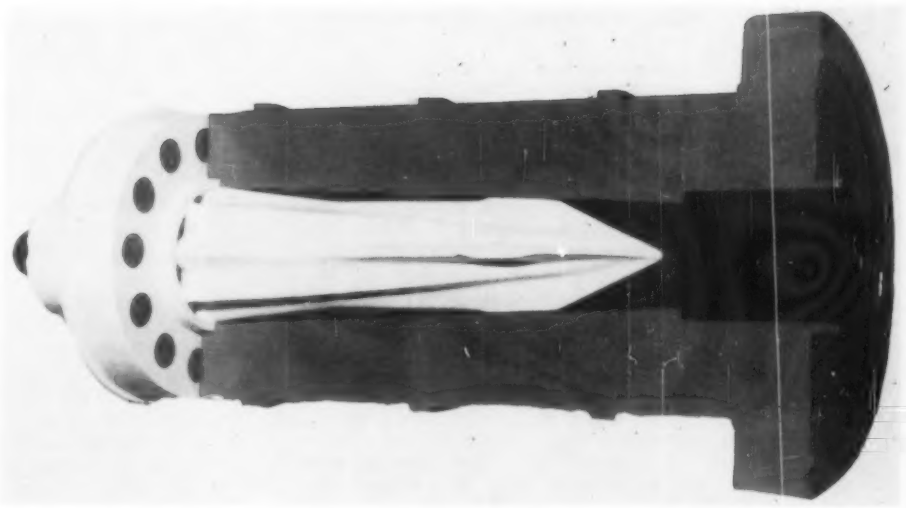


Figure 1. Model of the Conical Heat Chamber.

ONE OF THE BASIC parts of an injection molding press is the heat chamber. Since the beginning of injection molding, men have been striving to obtain a heat chamber more efficient in all respects. In the past, an improvement in one direction has meant accepting losses in other directions. Basically the chamber does one main job, that of converting solid particles into a liquid or viscous state so that the plastic can be molded, while at the same time transmitting enough pressure through itself to fill the mold.

In some heat chambers which have an excellent rate of plasticization, the pressure loss is so great that the effective pressure is reduced so that the chamber is not usable with normal injection cycles. In other chambers that have an average rate of plasticization, when materials such as polyvinyl chloride are used, the pressure loss becomes excessive. As a result even though certain qualities of the heat chambers are good and certain hard-to-mold plastics have other advantages, the average molder shys away from them.

In some heat chambers, to get a more efficient rate of plasticization, tortuous paths have been incorporated. Some rely on higher band temperatures while still others rely on a larger volume within the chamber, allowing the plastic to be in contact with the heat longer. In each case there are advantages for the average run of plastics; however with the vinyls and other materials that tend to decompose with heat, the advantages turn into liabilities.

Most heat chambers have a low watt density where the plastic is cold, and where the plastic is warmer the density stays the same, or even increases. Even with the more stable materials this factor tends to create a wide temperature differential in the plastic, causing silver streaks, discoloration and brittleness. One might say the natural thing to do would be to lower the temperature of the front zones. This will usually aid in correcting the problem, but will slow the rate of plasticization.

Cleaning the Heating Chamber

In most heat chambers there are blind spots where plastic can decompose or char. These are usually places where the stream slows down because of a sudden increase

This paper was presented at the Fourteenth Annual Technical Conference of SPE.

in area, resulting in a rapid decrease in pressure. In vinyl or like compounds which decompose into an acid, the condition becomes worse with time. A chain reaction is formed which can eventually ruin a heat chamber. With the average plastic, the chamber probably will be saved, but the charred material usually ends up in the molded piece as black specks. This can be just as costly. One remedy for this problem is to take the chamber apart for cleaning and inspection.

If one is a member of a large organization where all the facilities are available, the difficulties are minimized. To the average molder who doesn't have these facilities the problem is greater. Some heat chambers have a bolted construction, where the bolts are removed and the torpedo is taken out. Most torpedoes of this type have to be pressed out, and what happens when a bolt is frozen? With other chambers all one has to do is set the chamber in a lathe and cut a weld. It will fall apart. This is fine for those who have big enough equipment, but have you ever tried to weld one back together many times?

The Conical Chamber

The conical heat chamber is the result of specific designing to avoid these problems.

Figure 1 is a photograph of a scale model of the conical heat chamber. The chamber was designed to replace one on a nine ounce machine of a standard make. It is basically in two parts, the shell and the torpedo. The shell consists of a mounting arrangement, an outer diameter for heater bands and thermocouples, studs to secure the torpedo in place, a locating arrangement for the torpedo, a cavity for the ram bushing, a locating device for the feed mechanism and an inner cavity. The inner cavity is a segment of a single cone where the sides are straight, with the small diameter the same as that of the ram at the feed end, and a larger diameter at the stud end.

The torpedo is divided into two sections, the head and the torpedo proper. The head is strictly a utility section, having the holes which the studs pass through to secure the torpedo in place, a locating ring, a method for securing a nozzle, the openings for tubular heaters and thermocouples, and a series of holes on a conical axis to carry the plastic from the torpedo to the nozzle. The torpedo proper is made up of a basic body, with fins and ribs extending from it. The body starts at a rounded point about one quarter of an inch from the innermost position of the ram and flares out as a cone for approximately two inches. Here the cone changes to a lesser pitch, where it continues for about eight and one quarter inches to a point where it changes to a still lesser pitch, which is the same as that of the inner cavity of the shell. It continues until it blends smoothly with the innermost portion of the transfer holes.

Two inches from the root point, eight pyramid-shaped ribs emerge from the body on a conical plane. These ribs continue for about four and one quarter inches, where the pitch lessens and becomes parrallel to the middle cone pitch of the body. This pitch continues until the ribs meet the pilot face, where they actually become the webbing of the transfer holes. Superimposed on every other rib are fins which start at the root point, extending in a conical plane for about three inches. Here they meet the inner cavity wall. The surfaces face each other for two inches where they locate on a taper and lock the torpedo in place. The fins' outer surfaces then become parallel to the center axis until they converge with the ribs. The root, ribs, fins, and inner cavity are so designed that, when taking in account the bulk factor of the plastic, there is a uniform cross sectional area throughout the plastic flow, until the holes take the plastic to the nozzle. There is a fairly fast but smooth transition of area entering the holes.

Five Chamber Zones

There are five zones on this chamber, each controlled with a separate thermocouple. On the outside of the shell there are three zones; the back one of 4500 watts, the middle and the front ones of 3900 watts each. The torpedo has two; the head of 2000 watts and the torpedo proper of 5200 watts. The shell and the torpedo head zones are heated with band heaters and the torpedo proper is headed with tubular heaters, immersed in a zinc base alloy. The use of the zinc base alloy gives extra long life to the tubular heaters.

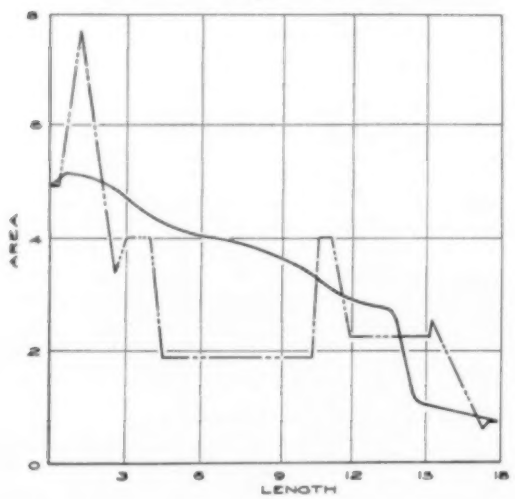
Figure 2 is a graph of plastic flow cross sectional area versus chamber length. The solid line is that of the conical chamber and the broken line represents the one replaced. The broken line has very rapid changes in area. Whenever the curve drops rapidly it is a restriction to flow.

Pressure is used to force the plastic through the restriction and is lost for any other use. As the plastic becomes more fluid, less pressure is lost going through restrictions. In the majority of the heat chambers similar rapid drops occur in the first half of the chamber, while the plastic is in a solid or semisolid form.

Note the absence of any abrupt changes in area of the solid line until almost the fourteen-inch line where the plastic actually enters the holes in the torpedo head. By this time the material should be as fluid as it ever will be, and therefore the pressure loss is at a minimum. When figuring the bulk factor of the plastic, assuming a factor of two with one half of it being compressed by the ram action alone, the curve is actually leveled off and becomes basically a uniform area curve. This, I believe, is the reason why the pressure loss in the conical chamber is reduced.

The area under each curve gives the volume the plastic occupies in the chamber. Here something unusual happens. The volume of the standard chamber is 50.94

Figure 2. Cross-sectional Area of Flowing Plastic as a Function of Length of Heating Chambers.



cubic inches, and the volume of the conical chamber is 59.84 cubic inches. The volume actually increased while the maximum diameter of the flow decreased. This allowed a thicker shell wall to be used which resulted in a stronger chamber.

In most of the existing heat chambers there is little if any change in relationship between two particles of plastic while going through the chamber. The plastic itself is relied on to transmit the heat. Being insulators, most plastics use a similar heat transfer relationship. Using the data prepared by A. L. Bird and Joe Eveland in their paper of Uniformity Considerations For Plastic Stock Temperatures (1) we see, using a wall temperature of 500°F, polystyrene will be heated to 450°F in the following time-thickness relationships:

Layer Thickness	Time-Seconds	Inches Rate Seconds
.031	3.6	.0086
.062	14.0	.0044
.250	230.0	.0011
.500	921.0	.0005

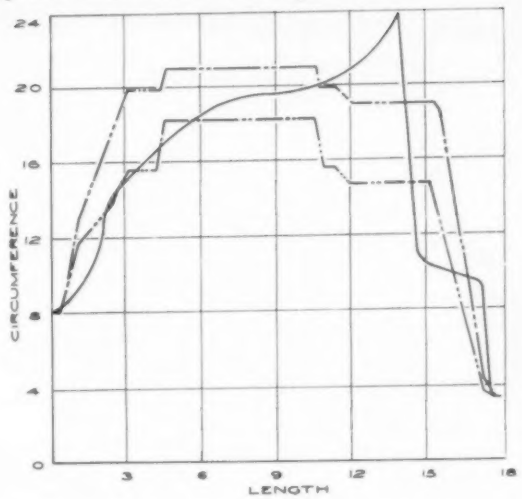
This relationship means that the material must be subjected to the heat a long time before it is melted for any appreciable thickness. The material next to the heating surface approaches the temperature of the heating surface, giving a temperature differential throughout the flow.

Melt Extraction Chambers

In melt extraction chambers as the plastic is melted it is skimmed off, allowing the colder material to come in contact with the heating surfaces. This method was able to heat the mass of plastic using the faster time rate. The conical chamber uses this same principal, only in a different way.

Figure 3 is a graph showing total circumference versus length. The solid line represents that of the conical chamber, while the upper broken line represents that of the replaced chamber. Note that the solid line continually increases until almost the fourteen-inch mark where it rapidly decreases. Over the same length the distance between the torpedo and the shell walls decreases. The areas stay the same, the distance between two surfaces decreases, and the circumference of each circle increases. Let us look at two of the basic areas. Figure 4, top, shows two basic areas A and B, both areas being equal. Area A represents the area at the ram end and area B represents the area further toward the nozzle end. As the plastic moves from one area A to the other B, let us see what happens. Figure 4, bottom, might describe the forces more clearly. Area C and D are equal, with C being a square representing a portion of A, and D being a rectangle representing B. The vertical sides represent the distance between the shell and torpedo walls and the horizontal sides represent the circumference. As the walls become more narrow force is exerted, as shown by the arrows. The plastic next to the walls, by reason of being more fluid, moves more easily. When the force is applied it tends to move the plastic in three directions; ahead along the cavity axis, to right angles with the cavity axis, and into any voids between the colder particles. This leaves the cooler plastic next to the heating surfaces, and therefore uses the faster melting rate. Each time the ram actuates, the cycle is repeated. Any fluid plastic that is forced between the cooler granules tends to retain its heat because it is surrounded by an insulator, but what heat is lost is used to heat the colder granules. Because the ribs gradually increase in height in relation to the torpedo base, additional mulling action is created. This

Figure 3. Circumference vs. Length.



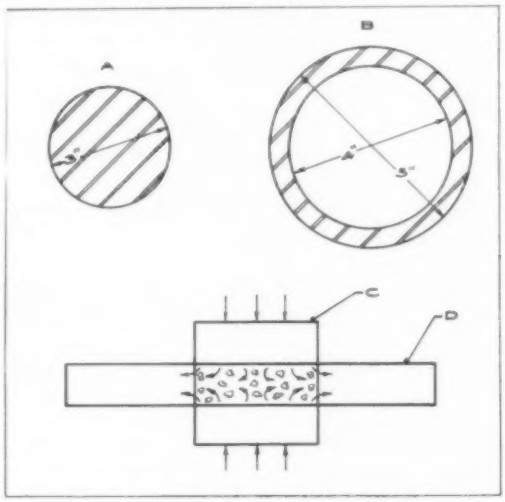
mulling action makes use of a higher plasticizing rate, and also tends to cut down the temperature differential through the plastic flow.

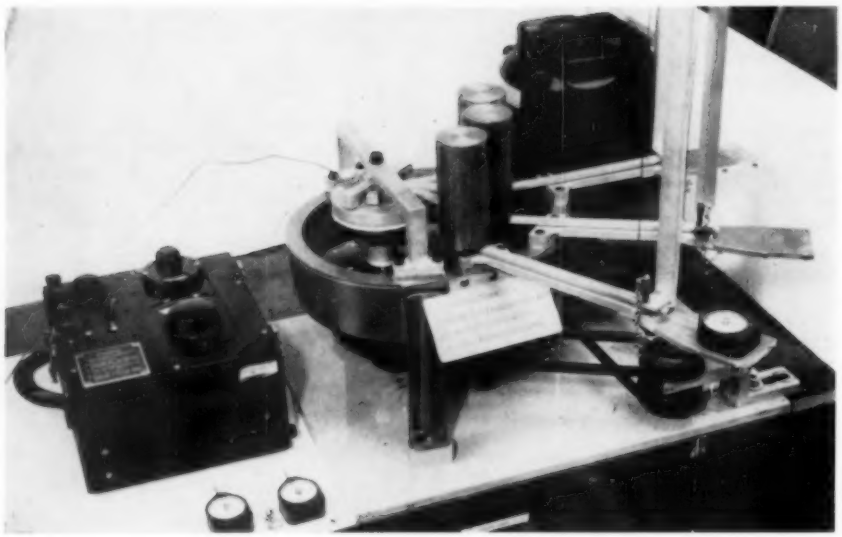
Advantage of Even Stock Temperatures

Going back to Figure 3 again, the area under each curve gives the actual area of heating surfaces of each chamber. A second broken line is found just below the first. This represents the effective circumferences due to the fact that the torpedo has no direct heat source. A 50% factor was used except in the area of the holes where a 75% factor was used on the torpedo only. The area under the second curve gives the effective heating area. The area of the conical chamber and the effective area of the replaced chamber were close; 260.16 square inches for the replaced chamber and 283.12 square inches for the conical chamber. Notice how the area is propor-

(Please turn to page 70)

Figure 4. Forces in the Heat Chamber.





Abrader for Measurement of Frictional Properties of Plastics.

Friction and Abrasion Characteristics of Plastics Materials

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The frictional characteristics of plastics materials and the resultant wear or abrasion properties are of great importance.

The work reported in this paper was carried out to determine the frictional properties of materials after extended periods of contact with metal riders at relatively high loadings and rates of speed. Most of the previous work reported in the literature gives the result of experiments in which new or freshly prepared surfaces were tested and only one traverse was made. This paper covers the design and construction of the equipment used, test procedures and general results.

Description of Equipment

Detail drawings of the assembly are shown in Figure 1.

The samples are 1/8 inch by 4 inch diameter discs. They are fastened to a horizontal turntable which is rotated by an appropriate drive. Metal riders (shown in Figure 1) are mounted on the underside of three concentric rings. Each ring contains three riders mounted 120° apart and equi-distant from the center of rotation. Force is applied to each ring by means of a yoke which bears on the ring at diametrical points. Spherical ends on the yoke fit into sockets on the rings to hold them in concentric position. The three yokes are held in position by a removable pin which fits in the frame and passes through a hole in the center of each yoke.

Long arms are attached at right angles to each of the yokes and are suspended near the ends so that the arms are horizontal. Provision is made so that weights can be mounted on these arms to provide a variable normal force on the sample.

Figure 1 shows the top view of the equipment and shows more clearly the relation of the three arms. Each ring and arm assembly operates independently. With this design it is possible to study the effect of different sliding speeds at the same time; the speed at the large ring is 4.4 times as great as the speed at the location of the riders on the small ring.

This paper was presented at the Fourteenth Annual Technical Conference of SPE.

The frictional force is obtained by measuring the tangential force exerted on the arms when the sample is rotated. These forces are measured at the ends of the arms by means of dynamometers manufactured by the George Scherr Company. Each arm is held in position by a removable stop pin. By removing the pin and placing the pointer of the dynamometer against the arm, readings can be taken at any time throughout the test.

Thermocouple wells are provided in each ring directly above one of the riders. With this arrangement temperatures can be measured throughout the run.

A photograph of the equipment is shown in the title figure. The machine is completely assembled and the location of the three arms with the weights in position can be seen. Another point to note in the title figure is the thermocouple wire and the potentiometer used to record the temperature changes. The dynamometers used to measure the force exerted on the arms are shown with one in position.

Figure 1. Detail of Test Apparatus.

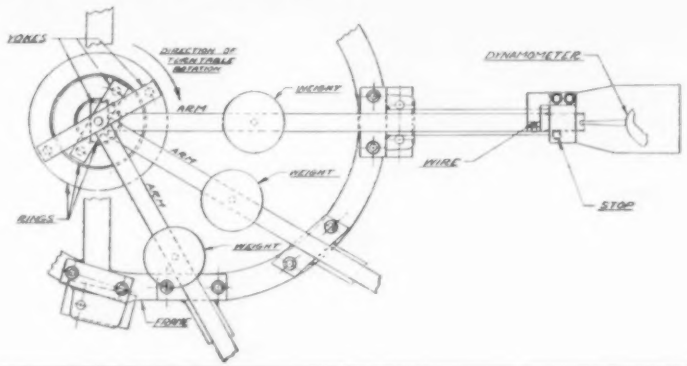


Figure 2. Normal Force on Sample.

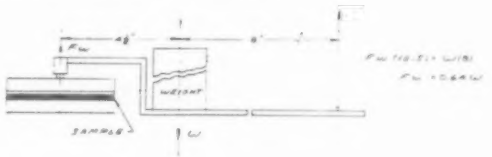
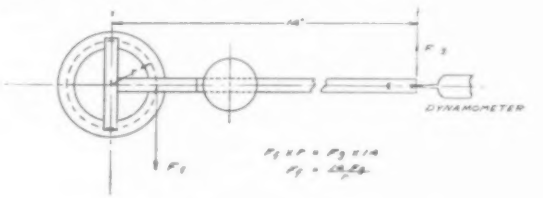


Figure 3. Measurement of Friction Force.



Calculation of Normal Force and Friction Force

The normal force exerted on the sample consisted of two forces:

1. The weight of the ring and the effective weight of the arm. These were constant for a given ring and were determined by weighing these items.
2. The second force is exerted by the weight placed on the arm. Figure 2 shows the arrangement and location of the weights. By taking moments about the supporting wire, the following relation was obtained:

$$(F_w)\ (12.5) = W\ (8)$$
$$\text{or } F_w = 0.64W$$

where F_w = force exerted by the weight placed on the arm, lbs.
W = weight, lbs.

For each ring, then, the normal force F_n is equal to the value 0.64W plus a constant, the constant being the weight of the ring and arm.

The friction force was obtained by first measuring the force exerted at the end of each arm with the dynamometers. From this value the torque was calculated as shown in Figure 3. Each arm was 14 inches long and "r" refers to the radius of each set of riders. The actual force at the riders can then be calculated as follows:

$$(F_f)\ (r) = (F_g)\ (14)$$
$$\text{or } F_f = 14\ F_g/r$$

where F_f = friction force at riders
r = distance of riders from center
F_g = reading on dynamometer
14" = length of each arm.

The coefficient of friction, u, which is defined as the ratio of the friction force to the normal force can then be calculated and expressed as follows:

$$u = F_f/F_n$$

Test Procedure

In making a run with a given material the sample was first cleaned with alcohol, weighed, and fastened to the turn-table. The machine was assembled and weights were placed on the arms. After starting the machine, readings were taken on the dynamometers at regular intervals; the temperature of each ring was also recorded. Each sample was run for at least 6 hours. At the end of the run the sample was removed, cleaned with alcohol, and reweighed.

By weighing the samples before and after each run a measurement of the abrasion resistance of each material was obtained. Additional abrasion data was obtained by weighing the riders before and after each run to determine whether any of the plastics were abrasive. No attempt was made to clean the samples or lubricate the riders during the test.

Test Conditions

In studying friction properties, it is necessary to know the sliding speed of the two materials, the normal force exerted on the sample, and the type of materials used.

Sliding Speed

The samples were rotated at a constant speed of 100 rpm. The linear speeds at the riders were calculated and are shown on Table I.

Experimental Results

Table I—Sliding Speed

Ring*	Sliding Speed in/min.	Speed ft/min.
A	1060	88
B	628	52
C	236	20

**The letters A,B, and C were arbitrary designations given to the 3 rings, A being the largest ring and C the smallest.*

Table II—Normal Force

Ring	Weight: gm	Normal Force: gm	Normal Force: psi
A	1888	1894	256
B	2850	2262	305
C	2850	2031	275

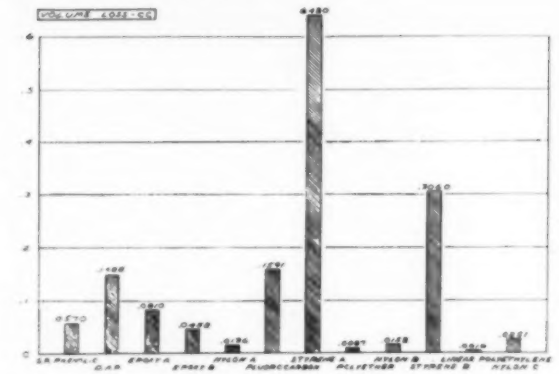
Table III
Materials Tested

Material	Type
Thermosets	
G. P. Phenolic	General purpose phenolic, wood flour filled
D.A.P.	Diallyl phthalate, orlon filled
Epoxy "A"	Epoxy molding compound 60% clay & 10% nylon flock filler
Epoxy "B"	Epoxy molding compound 68% clay & 3% nylon flock filler
Thermoplastics	
Styrene "A"	High heat, high impact rubber modified polystyrene
Nylon "A"	Swiss caprolactam nylon
Fluorocarbon	Polytrifuoromonochloroethylene
Polyether	Chlorinated polyether
Nylon "B"	Caprolactam nylon
Styrene "B"	Styrene acrylonitrile- rubber copolymer
Linear Polyethylene	Low pressure polyethylene (Ziegler Process)
Nylon "C"	Nylon 6-6

Table IV
Weight and Volume Loss

Material	Weight Loss-gm	Sp. Gr. Volume	Volume Loss-cc
G. P. Phenolic	.0768	1.35	.057
D.A.P.	.1948	1.31	.149
Epoxy A	.1456	1.80	.081
Epoxy B	.0893	1.81	.045
Nylon A	.0155	1.14	.013
Fluorocarbon	.3342	2.10	.159
Styrene A	.6735	1.05	.642
Polyether	.0122	1.40	.009
Nylon B	.0172	1.13	.015
Styrene B	.2843	0.93	.306
Linear Polyethylene	.0015	0.95	.002
Nylon C	.0275	1.09	.025

Figure 4. Volume Loss of Samples.



Normal Force

The weights used and the normal force on each of the arms are shown in Table II.

The weights were selected so that the normal force on each ring was nearly the same. The normal force was in the neighborhood of 2000 grams or about 4.5 pounds. The loading in pounds per square inch was also calculated. The riders used were .093 inch in diameter and had a slight radius at the circumference. The normal force in psi was calculated assuming 80% of the surface contacted the plastic sample; the resultant load ranged from 250 to 300 psi.

Hardened beryllium copper contacts were used in all the test work reported in this paper.

Materials Tested

Twelve materials were evaluated in these tests; these included both thermoset and thermoplastic materials. A description of these materials is given in Table III.

The thermoset materials were all compression molded into 4 inch diameter discs. Of the thermoplastic materials, the following were obtained from the suppliers as injection molded discs: the 3 nylons and the chlorinated polyether. For three of the materials, the 2 styrenes and the fluorocarbon, samples were cut from sheet stock. Samples of the low pressure polyethylene were prepared by compression molding.

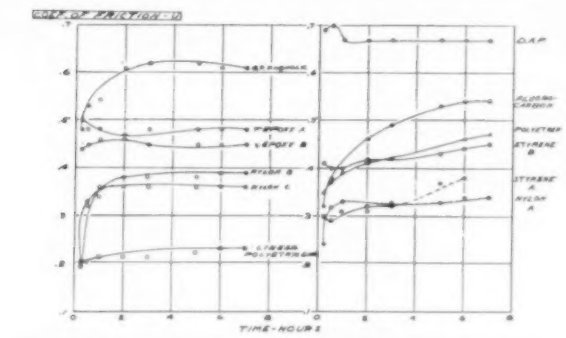
The abrasion properties of the plastics were obtained by determining the weight loss of the plastic samples and the beryllium copper riders. The weight and volume loss of the samples after 7 hours of test is shown in Table IV.

Test Results

The value for volume loss in Table IV was obtained by dividing the weight loss in grams by the specific gravity. This is a better value for comparison purposes since it gives an indication of the amount of material worn away and essentially the depth of the grooves worn by the riders. These values are shown graphically in Figure 4.

From Figure 4 it can be seen that the least amount of wear was obtained with the low pressure polyethylene, followed closely by the polyether. The three different nylons wore about the same amount and ranked next in resistance to abrasion. The amount of wear exhibited by the fluorocarbon samples was surprisingly high. The

Figure 5. Friction Characteristics of Plastics Materials. (Riders Be, Cu. Normal Load 256 psi. Sliding Speed 88 feet per minute.)



greatest amount of wear was encountered with the two styrenes; with styrene A it was necessary to stop the test after six hours because the wear was so great. All other samples were tested for seven hours.

The abrasiveness of the plastics was determined by measuring the weight loss of the riders. The riders originally weighed approximately 0.14 gm each. Weight loss for each ring is the total weight loss of 3 riders. Only the four materials listed in Table V caused any measurable amount of wear on the riders.

The D.A.P. material was the most abrasive, and the weight loss of the riders ranged from 8.2% for the largest ring to 1.8% for the small ring. Styrene B and the two epoxy molding compounds showed a slight amount of wear on the riders, the weight loss being less than 2% in all cases. For the rest of the materials the wear on the riders was negligible, that is, less than 0.1%.

The coefficient of friction was determined as previously outlined. Readings were taken at regular intervals over the 7 hour test period and values were calculated for the coefficient. The temperature of each ring was also recorded throughout the run. Values for the **maximum** coefficient of friction and the **maximum** temperature rise for each material are shown in Table VI.

With such a large number of materials it is difficult to pick out the differences between them. However, by pointing out a few examples, these differences will be readily apparent. The lowest coefficient of friction was exhibited by the low pressure polyethylene and was in the neighborhood of 0.2. At the other extreme we have the two thermoset materials—a phenolic and a diallyl phthalate with coefficients of 0.6 to 0.7. The three nylon materials again ranked nearly the same, having friction coefficients of 0.3 to 0.4. As was noted with the abrasion data, the fluorocarbon had a surprisingly high coefficient of friction, being in the neighborhood of 0.5.

To show more clearly the differences between the materials, the frictional coefficients were plotted over the 7 hour period. These are shown in Figure 5. The values presented are for the largest ring only, since similar curves for the other two rings show practically the same relationship between materials.

As is noted in Figure 5 the test conditions were as follows:

Normal load — 256 psi
Sliding speed — 88 ft/min
Riders — Beryllium copper

Table V—Wear on Riders

	Weight Loss					
	A		B		C	
Material	gm	Percent	gm	Percent	gm	Percent
DAP	.0345	8.2	.0248	5.9	.0075	1.8
Styrene B	.0072	1.7	.0030	0.7	.0007	0.2
Epoxy B	.0072	1.7	.0045	1.1	.0025	0.6
Epoxy A	.0018	0.4	.0012	0.3	.0005	0.1

Table VI

Coefficient of Friction and Temperature Rise

Material	Max. T. Rise °F			Max. Coef. Friction		
	A	B	C	A	B	C
G.P. Phenolic	.61	.64	.66	51	62	56
D.A.P	.67	.66	.70	53	62	56
Epoxy A	.46	.40	.45	36	41	37
Epoxy B	.50	.44	.44	39	43	38
Nylon A	.34	.34	.40	24	29	26
Fluorocarbon	.56	.48	.44	43	50	36
Styrene A	.38	.37	.36	32	37	35
Polyether	.47	.41	.37	43	49	43
Nylon B	.39	.39	.37	28	33	26
Styrene B	.44	.36	.36	47	50	44
Linear Polyethylene	.23	.23	.23	18	19	18
Nylon C	.36	.40	.44	33	41	39

The time scale on the abscissa is in hours and the curves all start at 15 minutes. Readings were made earlier than 15 minutes and as expected, somewhat lower values were obtained. This was particularly true of those materials having the highest coefficients of friction.

From Figure 5 it can be seen that quite a range was observed in the frictional coefficients of these materials. The linear polyethylene had a very constant coefficient over the period of the test. The 3 nylons showed a rather sharp increase in frictional coefficients in the first hour and then leveled off. The coefficients for the fluorocarbon and the chlorinated polyether continued increasing throughout the test with very little sign of leveling off. With the thermoset materials the frictional coefficient started out rather low but within a short time the riders broke through the surface skin and the coefficient increased rapidly to the values shown in Figure 5.

Conclusions

Because of the large number of materials evaluated in this work, it was not possible to study completely the effect of variables such as sliding speed and normal load for a given material. The equipment was designed with the primary intention of pointing out differences between the materials in regards to characteristics of friction and abrasion. This was accomplished very successfully.

The equipment proved to be flexible and reliable in studying the frictional properties of plastic materials. Plastic riders can be used in place of metal riders to study the effect of plastic to plastic contact. With a variable speed drive the effect of sliding speed could be studied more completely. Since the 3 arms operate independently, a number of tests can be made on one sample; the normal force can also be changed very quickly and simply over practically any range. ★ ★

A New Family of . . .

Heat Resistant Urethane Polymers

This paper describes a recent advance in the technology of urethane polymers whereby distinctly improved thermal stability can be built into urethane foams and other urethane products. The data to be presented are derived principally from work on rigid cellular products. Our experience indicates that a corresponding improvement in the heat resistance of flexible cellular and of non-cellular urethane products can also be achieved by the same means.

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Although the American chemical industry has shown a tremendous interest and activity in urethane foams during the past several years, development emphasis has been primarily on the resin rather than the isocyanate component of these polymers. This emphasis has resulted in an increasing variety of unique polyesters, polyethers, and other polyfunctional reactive components for the production of urethane foams.

Rigid urethane foams have been of interest because of their ability to be formed in place, to adhere tenaciously to a wide variety of surfaces without a separate bonding agent, and to support high compressive loads relative to their weight. As engineering or structural materials the previously known foams have inadequate strength at elevated temperatures for use in many applications where their mechanical, acoustical, and other properties would otherwise be desirable. This lack of heat resistance may result in shrinkage and severe distortion when the foam is exposed to high temperatures, or the foams may soften, lose their strength or even decompose at the elevated temperatures. In any case this sensitivity to heat constitutes an important limitation on the industrial usefulness of urethane foams and other types of urethane products.

Improved Heat Resistance

Experience indicates that products made with isocyanates such as the tolylene diisocyanates, even utilizing highly branched resin co-reactants, become unserviceable at 200 to 250°F or below. Numerous efforts have been made to improve the heat resistance of the urethane foams to the point where they can be used under more rigorous conditions. One of the more promising approaches has been one involving chemical modification of tolylene diisocyanate by pre-reacting it with a triol to yield a complex triisocyanate. This complex triisocyanate is then foamed with a suitable polyester or polyether in the conventional manner. The triol may be a simple polyhydroxy compound such as trimethylolpropane or hexanetriol, or it may be a highly branched, hydroxy-terminated polyester containing three or more hydroxyl groups per molecule. Compositions of the preceding types are commercially available and are recommended for the production of cellular materials which are to be used at elevated temperatures. While the use of these modified polyfunctional isocyanates does improve the heat resistance, our experiments, coupled with statements in the published literature, indicate that this approach is successful in increasing the maximum service temperature only to about 250 to 300°F, depending on density, dimensional stability and load-bearing requirements. This degree of improvement is not adequate to qualify rigid urethane foams as high temperature engineering materials. Nevertheless it is of interest to note that the improvement was primarily brought about by a development in the isocyanate component, and suggests that it is unfortunate that industrial emphasis on development of new isocyanates has not paralleled that of the resins.

The Need for New Material

This need for a new isocyanate component has been met by the development of a new polyisocyanate, which is now being offered to the urethane field for use in high temperature urethane products of the type described in this paper.

The introduction of this new product, polymethylene polyphenylisocyanate, will open a new range of end products to complement the present versatile urethanes. Extensive formulation and testing has been and is now being carried out.

Polymethylene polyphenylisocyanate*, is a dark amber somewhat viscous liquid. It contains both ortho and para substitution and hence a differential degree of re-activity between isocyanate groups is to be expected.

This paper was presented at the SPE Upper Midwest RETEC, "Isocyanate Symposium."

Table I
Rigid Foam Formulations

I

*"Selectrofoam" 6002	— 100 parts
**Witco 77-86	— 5 parts
n-Methylmorpholine	— 2.5 parts
Water	— 4.5 parts
Polymethylene Polyphenylisocyanate	196 parts

*Pittsburgh Plate Glass
**Witco Company
*Dow Corporation

II

*Polyethylene Glycol 300	— 100 parts
Witco 77-86	— 1.6 parts
n-Methylmorpoline	— 2.0 parts
Diethylethanol Amine	— 3.33 parts
Water	— 1.6 parts
Polymethylene	

Table II
PAPI Compressive Strength
Humid Aged 7 Days at 158°F - 100% Relative Humidity

Batch No.	Density-Lbs. Cu. Ft	Compressive Strength in psi at 10% Aged	Unaged (Control)
86	3½	62	62
109	5	81	78
111	7	143	138
112	10½	266	284
108	13	485	502

The present product is composed of a family of low molecular weight polymers and has the average composition of the trimer.

Many advantages are apparent in this compound, among which are the high functionability which makes possible the preparation of a wider range of cross-linked urethane polymers than can be produced from diisocyanates, a low volatility resulting in a lower toxicity hazard even at higher temperatures, and an advantageous viscosity which eliminates the necessity for prepolymer techniques where so desired. Because of this viscosity advantage, successful "one-shot" foams have been repeatedly produced with various commercial polyethers.

Table I shows two typical formulations for rigid foams produced from polyether and polyester. These foams are light tan in color and have a fine, uniform cell structure. Average time to reach their maximum rise is 1-2 minutes and they are tack-free in 3-5 minutes.

In order to obtain maximum properties these foams are post-cured for 18 hours at 400°F in a circulating air oven.

The Physical Data

The physical data in the figures have all been derived from samples which were machine-produced from these formulations.

The two TDI-based foams shown in Figure 1 were produced from commercially available polyfunctional adducts such as those produced by the reaction of TDI with 1, 2, 6 hexanetriol, trimethylolpropane or a branched polyester. We note that all the foams have substantially equal compressive strengths at room temperature but at 325°F the difference between polyphenylisocyanate based foams and those produced from TDI is striking.

The curves presented in Figure 2 illustrate the high retention of original compressive strength at various densities which is a unique property of rigid foams produced with polyphenylisocyanate. Up to 400°F these foams undergo a 2% volume change with no visible distortion. It may be noted that other tests run at 500 and 600°F showed an apparent increase in compressive strengths. This can possibly be explained by the increase in density due to the larger volume shrink experienced at these temperatures. It is also of interest to report that these samples were conditioned at the high test temperatures for 24 hours prior to testing which is in itself an indication of the long-term resistance to these extreme temperatures.

Figure 1. Compressive Strength of Modified TDI and PAPI Foams.

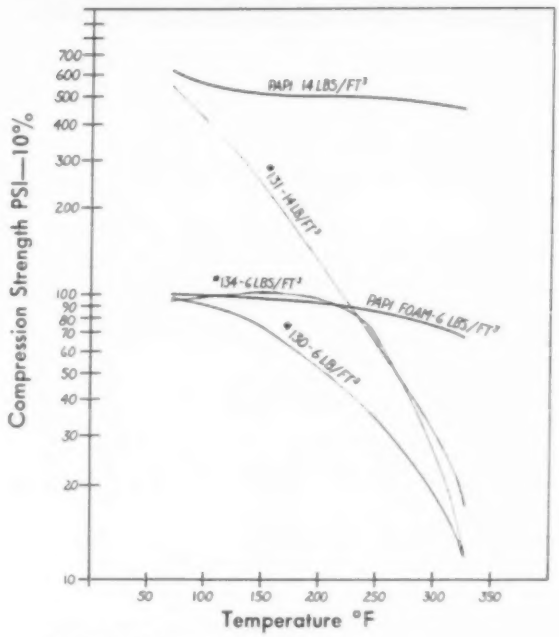


Figure 2. Compressive Strength at Ten Percent Deflection.

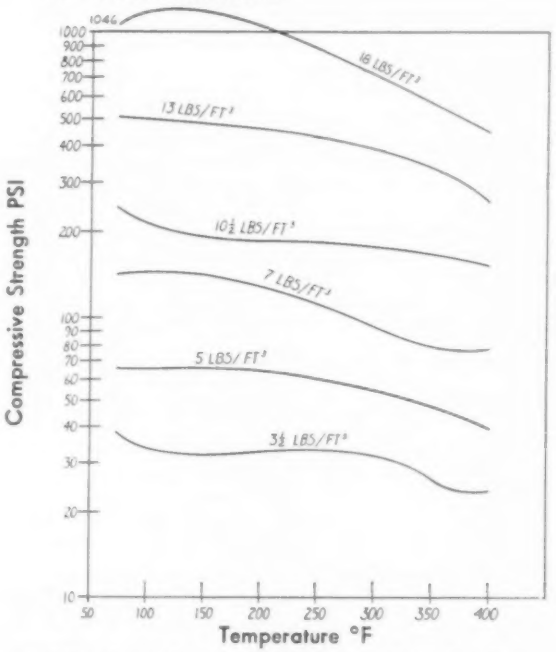


Figure 3. Tensile Strength of Modified TDI and PAPI Foams.

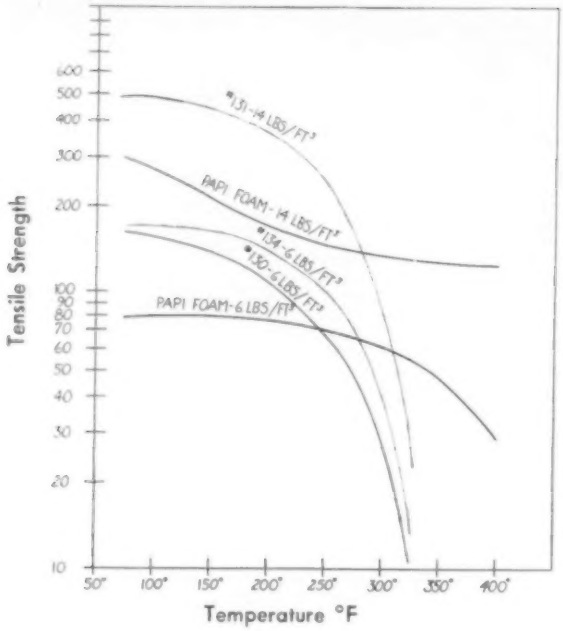
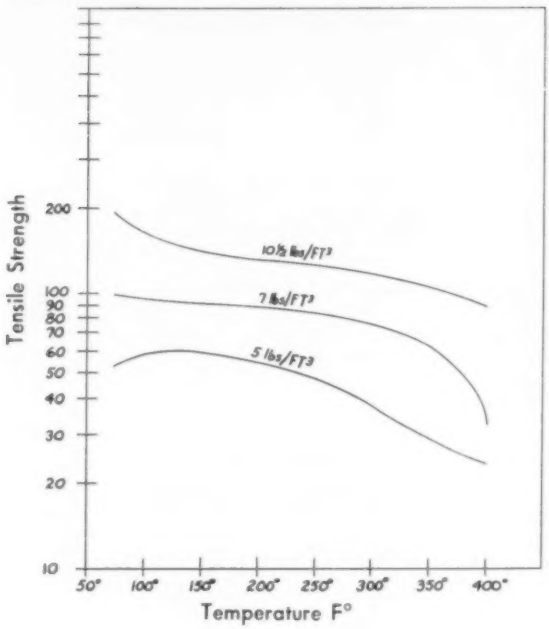


Figure 4. Tensile Strength of Rigid PAPI Foams.



Little or no deterioration of compressive strength properties was apparent at the conclusion of this test. A similar sample which had been foamed on a steel plate was subjected to a six-week test at 95°F and 100% relative humidity with no loss of adhesion.

In Figure 3 the superior temperature resistance of polyphenylisocyanate-based rigid foams is evidenced. At least 325°F polyphenylisocyanate foams have retained a substantial portion of their tensile while the TDI-based foams have deteriorated to unusable values.

Figure 4 indicates the tensile behavior pattern of polyphenylisocyanate rigid foams of intermediate densities. Again we see the substantially high strength retention of these foams at the higher temperatures. At 300°F other known urethanes would require more than twice the pictured densities to attain similar strength constants.

Table III
Compression Set - Rigid PAPI Foam

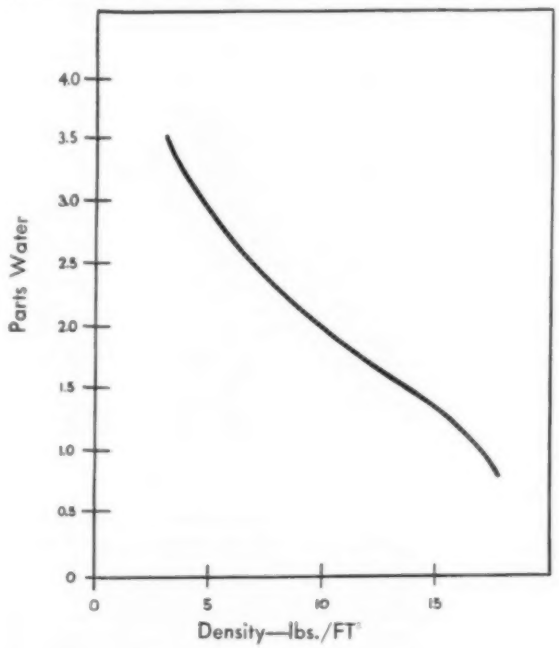
Density - lbs./cu.ft.	% Set
3½	4.2
5	4.5
7	6
10½	4.9
13	5.3

These tests of Table III were run at a modification of ASTM-D-395-52T, Method "B". Samples were compressed to 90% of original height and maintained for 22 hours at 158°F. Samples were allowed one half recovery at room temperature prior to measuring.

Figure 5 indicates the required water ratio to produce a foam of predetermined density. Witco 77-86 was the emulsifier used in this system and it should be mentioned that use of other emulsifiers will substantially alter the water ration required for a given density.

While the data which have been presented have been derived from work on rigid foams, other experiments of a

Figure 5. Density as a Function of Water Content per 100 parts of 6002 Resin.



preliminary nature on flexible foams, elastomers, resins, and coating compositions have also indicated results of promise. The heat resistance, workability, and in some cases, solvent resistance of these polymers indicate that polyphenylisocyanate will be useful in these formulations.

We wish to acknowledge and thank Mr. Robert Shine and Mr. Ronald Peterson for their assistance on the work presented in this paper. ★ ★

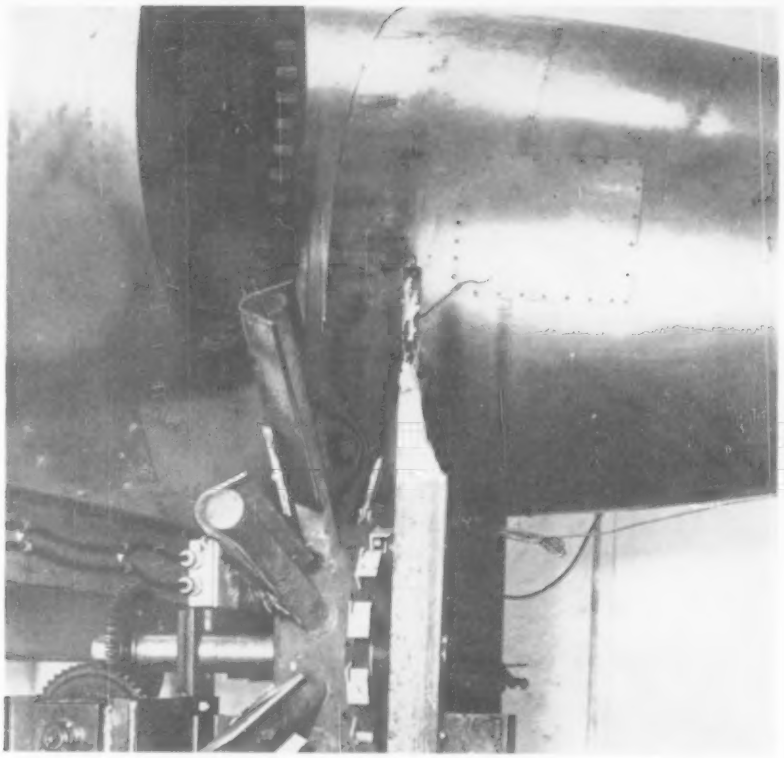


Figure 1. Plastic test pieces mounted on spokes and rotated in jet-plane after-burner blast for measured intervals, to determine heat-blast erosion effects.

Heat-Blast Erosion Effects on Reinforced Plastic Laminates

N. B. Miller and E. L. Strauss

The Martin Co.
Baltimore, Maryland

HEAT RESISTANT PLASTIC laminates exhibit desirable mechanical and thermal properties in the environments associated with high speed flight. At temperatures above 250°F. these reinforced plastic materials tend to lose their strength at a slower rate than do the familiar light metals such as aluminum commonly used for aircraft. In addition, the low thermal conductivity of plastics confines the highest temperatures to the exposed exterior surface while the remainder of the laminate remains appreciably cooler. Therefore, airframe structures subject to aerodynamic heating can often be designed more efficiently with reinforced plastics than with metal although at room temperature the reverse is true.

During flights of rockets and guided missiles, aerodynamic surfaces are in contact for short periods of time with a high temperature, high velocity air stream. This environment is capable of causing severe thermal degradation and erosion in reinforced plastics. To determine the extent of this change, a test program was initiated utilizing a jet engine with afterburner as a source of high temperature, high velocity gases. This paper presents the results of the investigation.

Experimental Procedure

The test specimens were fabricated as shown in Table I. Matched metal tooling was used. The materials selected for evaluation were:

1) A heat resistant phenolic-glass fabric laminate;
2) A silicone resin-glass fabric laminate;
3) A triallyl cyanurate polyester-glass fabric laminate;
4) An asbestos-phenolic laminate.

This paper was presented at the Fourteenth Annual Technical Conference of SPE.

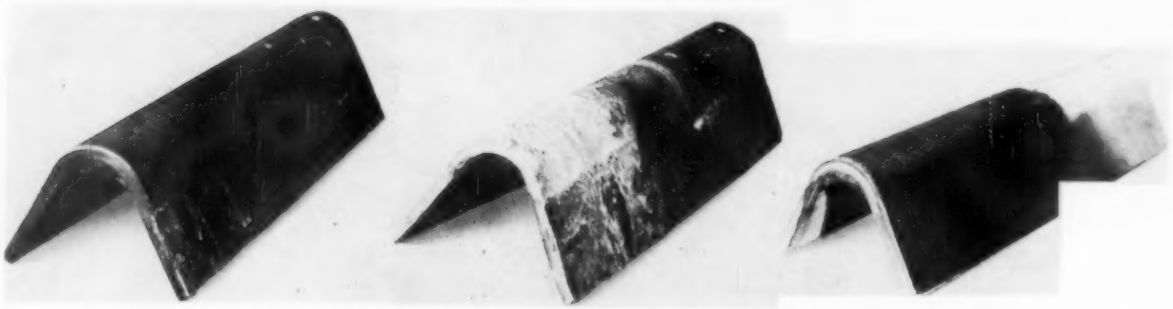
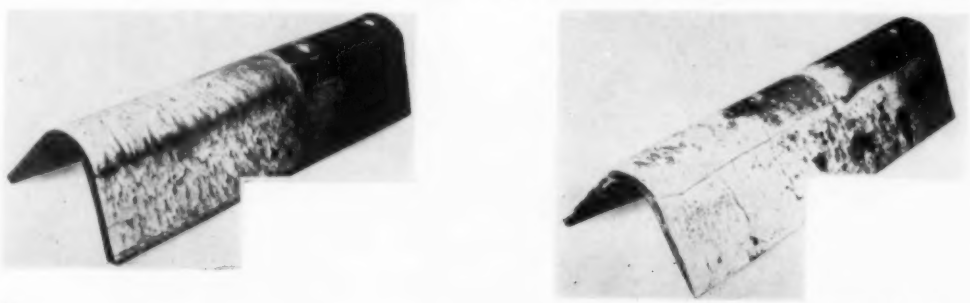


Figure 5. (Left) Appearance of 91-LD phenolic laminate after 12-second exposure to afterburner blast. Resin has been removed from the surface of the laminate. There is some delamination and blasting away of glass fabric near the edges. Slight delamination is visible on the right hand side of the end. Weight loss is 4.5 per cent. Figure 6. (Center) Appearance of 91-LD phenolic laminate after 60-second exposure to afterburner blast. Surface damage to laminate is extensive. Several layers of glass cloth have been eroded away. Resin has been almost completely burned away on end and delamination to interior of laminate is extensive. This specimen was exposed to two afterburner runs with a short interval between runs because of the danger of overheating the jet engine. Weight loss is 11 per cent. Figure 7. (Right) Appearance of DC-2106 silicone panel after 12-second exposure to afterburner blast. Little damage at this point, only surface charring. Beginning of delamination is seen on end of laminate. Negligible weight loss is under one per cent.

Figure 8. (Left) Appearance of DC-2106 silicone after 60-second exposure to afterburner blast. Several layers of glass cloth have now been fused and eroded away; fused glass forms a monolithic layer over the entire heated surface which has begun to spall in places. Panel has begun to thicken due to complete breakdown of interior. Weight loss is 3 per cent. Figure 9. (Center) Appearance of laminac 4233 polyester after 12-second exposure to afterburner blast. Panel is badly damaged even though there has been little heating. Afterburner was off during this run. Impact of blast on brittle polyester resin is enough to cause delamination. Weight loss is 5 per cent. Figure 10. (Right) Appearance of laminac 4233 polyester laminate after 36-second exposure to afterburner blast. Surface is now composed almost exclusively of melted glass and areas where these pieces have cracked away. Interior of laminate has delaminated severely. Weight loss is 17 per cent.

Figure 11. (Left) Appearance of pyrotex 9526D1 asbestos phenolic after 12-second exposure to afterburner blast. Surface resin completely removed, surface layers of asbestos have cracked but are still in place. Weight loss is about 1.1 per cent. Figure 12. (Right) Appearance of pyrotex 9526D1 asbestos phenolic laminate after 60-second exposure to afterburner blast. Appearance is similar to other panels. Large pieces of asbestos have started to spall off the sides and a large section has loosened along the entire cross section. Interior delamination in this specimen is somewhat less than those with shorter exposures. Reasons unknown. Weight loss is 10 per cent.



Material	Cure Temp °F	Pressure, psi; time, min	Post Cure	Remarks
CTL-91-LD	300	200	24 hours at 250°F	Preheated mold to
Phenolic-glass		30	24 hours at 300°F	250°F.
181 Volan A, 31 plies, prepreg			24 hours at 350°F	
Polyester-Laminac	240	200	1 hour at 150°F	Cold mold—25 to
4233–5% Sb_2O_3–glass		30	1 hour at 200°F	30 minutes in
			1 hour at 250°F	press before cure
181 Volan A, 31 plies,			3 hours at 250°F –400°F	temperature was
Wet lay-up			24 hours at 400°F	reached. Wet lay-up.
DC-2106-Silicone-glass	325	50	16 hours at 150°F	Preheated mold to
28 plies, 181 heat cleaned		90	25° per hour to 500°F	300°F.
glass, prepreg			24 hours at 500°F	
Pyrotex-9526 D1	325	200		
Phenolic-Asbestos		60	24 hours at 250°F	Cold mold.
77 plies,			24 hours at 300°F	
prepreg			24 hours at 350°F	

Table I

Procedure for Fabrication of Test Specimens

In addition, a number of laminated specimens containing supplementary heat-resistant coatings varying in thickness from 10 to 60 mils were evaluated.

The test specimens were 12-inches long by ¼-inch thick and formed a 60-degree wedge with a one-inch leading edge radius (Figure 2).

The specimens were mounted on a wheel and were rotated into the blast of an Allison J-71 jet engine afterburner. Approximately a six-inch length of each panel was exposed to the direct afterburner blast, as shown in Figure 1. The temperature of the blast was approximately 3000°F and the gas velocity was approximately 2560 feet per second, Mach 1. The time of exposure was controlled by stopping the wheel with the test panel extending vertically into the blast. The exposure times were varied from 12 to 60 seconds, and included the time from the instant the test panel entered the blast to the time it was completely out of the blast.

The following determinations were made on the exposed test samples:

1) *Weight loss*—the specimens were weighed before and after exposure;
2) *Visual examination*—A visual examination was made to determine depth of charring of plastic, fusion of glass, erosion of glass and plastic, and delamination;
3) *Resin Content*—Specimens for resin content determinations were taken from both the top portion (exposed area) and the bottom portion (protected area) of the test panels;
4) *Strength Retention*—V-shaped slices were cut from the top and bottom portions of the test panels and tested to failure in compression at room temperature.

Figure 2. Test specimen before exposure.

Test Results

The results of this investigation are qualitative rather than quantitative. The data, however, permit the rating of materials with respect to the properties affecting their strength and thermal stability in the test environment. Weight loss, surface erosion, glass fusion, and the depth of charring give an indication of the relative thermal stability of the materials. Delaminations and compressive strengths are a measure of the relative strengths of the materials. It is necessary to distinguish between strength and thermal stability since the material with the greatest degree of thermal stability does not necessarily exhibit the best strength properties. A rating chart is shown in Table II.

Weight loss and compressive strength changes are compared in Figures 3 and 4. Resin content results were very erratic because of delamination, erosion and tearing away of surface layers. For this reason these results are not reported.

The glass fabric-phenolic specimens exhibited a considerable weight loss at exposure times in excess of 30 seconds. Glass fusion and resin charring were severe; however the material retained a fair degree of strength. Delamination was less pronounced than in any of the other materials investigated.

The asbestos-phenolic specimens exhibited only slight surface erosion. Resin charring and weight loss were less extensive than those sustained by the glass fabric-phenolic material, but delaminations were more pronounced. Compressive strengths of the asbestos-phenolic were higher than those of any of the other plastic laminates.

The glass fabric-silicone laminates exhibited no appreciable surface erosion and an extremely low weight loss. Glass fusion and resin charring were less severe than with other materials investigated. Delamination, however, was widespread and the strength of the material was poor.

The glass fabric-polyester laminates exhibited severe surface erosion, glass fusion, and resin charring, as well as extensive delaminations. Strengths compared favorably with the phenolic-laminates for very short exposure times, but decreased sharply as exposure times were lengthened.

Discussion of Test Results

Reinforced plastics have limited life above the temperature at which decomposition of the resin occurs. The exact temperature at which decomposition takes place varies from one material to another but at the present time is below 600°F for all resins. The decomposition does not occur all at once, but takes place slowly and quite smoothly. There is a time interval during which the laminate maintains its strength at temperatures above the decomposition point of the resin.

There are several other factors that affect the high-temperature properties of reinforced plastics. Silicone resins tend to soften as the temperature is raised. This softening is not permanent and the silicones will recover their room temperature properties on cooling if they have not been heated beyond their decomposition points. The coefficient of thermal expansion of the resin is much greater than that of the reinforcing material in a glass fiber or asbestos laminate. There is some tendency toward breaking the bond between resin and reinforcement in a laminate because of the high internal stresses set up which result in a loss of physical properties. The presence within the laminates of substances which decompose and give off volatiles at high temperatures can cause high internal pressure that will often result in internal delamination and blistering. If the laminate is suddenly exposed to high temperatures, the surface layer of resin is often burned away, leaving a porous layer of reinforcement that insulates the inner structure from the high temperature and retards decomposition.

At temperatures above 1000°F the reinforcement is affected. Asbestos begins to lose its water of crystallization at about 1100°F and the fibers lose much of their original strength as a result. Temperatures still higher than this will finally melt the fibers. Glass fibers melt in the range of 1400°F-2000°F. There is, therefore, a progressive attack on various components of a reinforced plastic laminate starting with thermal stresses in the bond between the reinforcing fibers at relatively low temperatures, advancing through resin decomposition and ending finally with destruction of the reinforcing fibers themselves.

The severity of damage to the reinforced plastic specimens during high-temperature blast exposure increases with exposure time. The nature of the damage sustained by the various materials is similar for equal exposure times. The differences in behavior of the various investigated materials are of degree only.

Damage to glass fiber laminates progresses in the following manner: (Figures 5 through 10)

Twelve-second exposure—surface charred, slight delamination near surface;

Eighteen-second exposure—surface resin completely removed, beginning of fusion on outer layer of glass fabric, slight internal delamination;

Figure 3. Variation of Weight Loss of Uncoated Panels with Exposure Time.

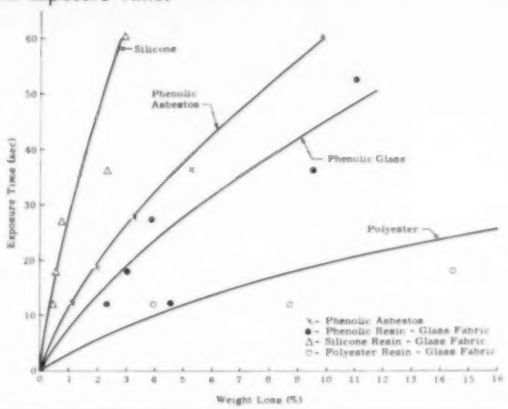
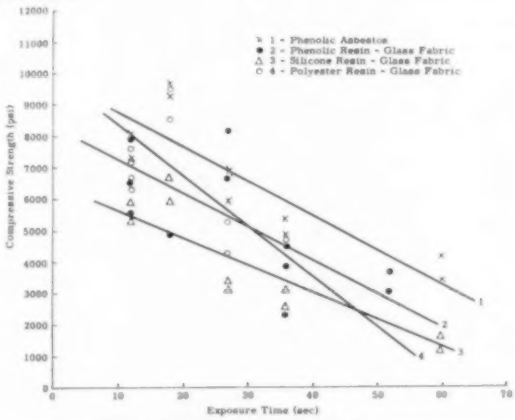


Figure 4. Variation of Compressive Strength with Exposure Time.


x 1 - Phenolic Asbestos
● 2 - Phenolic Resin - Glass Fabric
△ 3 - Silicone Resin - Glass Fabric
○ 4 - Polyester Resin - Glass Fabric
Compressive Strength (psi)
Exposure Time (sec)

Twenty-seven-second exposure—fusion of glass widespread but still largely confined to the surface, laminations spreading and forming visible gaps;

Thirty-six-second exposure—extensive damage to surface, several layers of glass fiber fused or eroded, extensive delamination between interior layers;

Sixty-second exposure—layer of fused glass over the entire exposed surface, material in the interior of the laminate beginning to break down, warping of the specimens appreciable, gaps formed in the interior from delamination;

The deterioration of the asbestos-phenolic laminates progresses in a similar manner except that the fusion of the glass is replaced by progressive dehydrating and

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Table II

The Optimum Material for High-Temperature Applications is Listed as No. 1

Material	Weight Loss	Depth of Charring	Surface Erosion	Delamination	Exposed Area	Non-Exposed Area	Average Ratings
Glass-Phenolic	3	3	3	1	2	2	2.33
Asbestos-Phenolic	2	2	2	2	1	1	1.67
Glass-Silicone	1	1	1	3	3	3	2
Glass-Polyester	4	4	4	4	4	4	4

New Surface Coatings Based on Diisocyanates

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Since antiquity, the usual process for securing protection of a surface against various environmental conditions has involved the use, in one form or another, of naturally occurring oils possessing conjugated olefinic unsaturation. It is true that the past fifty years have seen important modifications in the way in which these natural oils are used. Years ago, it was "lead and oil"; now we talk about alkyds and other synthetic resins. However, the process of conversion of liquid films into durable, solid coatings remains essentially as it has for centuries.

WHENEVER COATINGS CHEMISTS meet there are arguments about the exact mechanism of the drying process but it is generally conceded that the change from liquid to solid results from combination of the double bonds in one molecule with those of another, through the agency of the oxygen of the air which is in contact with the film.

We owe to the efforts of German scientists during World War II the development of a new approach to surface protection. The basic chemistry of this new approach involves the reaction of isocyanate groups in one component of the composition with active hydrogen atoms in the other component.

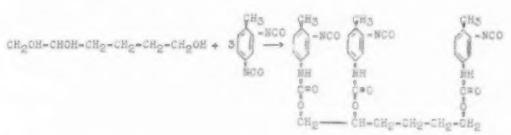
Fundamental Isocyanate Reaction

$$-NCO + -H^* \rightarrow -NHCO-$$

There are a variety of ways in which coatings of this type can be made, and with their typical thoroughness the Germans investigated practically everything feasible in the German economy.

One of the most talked about of these isocyanate coatings is made by the use of triisocyanates in combination with special polyesters containing free hydroxyl groups. The triisocyanates are the reaction product of various triols, such as hexanetriol, with three mols of diisocyanate.

Triisocyanate from TDI and Hexanetriol



The polyester is made by the reaction of various polyols, such as ethylene glycol and hexanetriol, with such dibasic acids as adipic and phthalic. The following table illustrates some of the combinations which the Germans developed.

Table I
Polyesters For Use in Urethane Coatings

Desmophen:	300	800	800 S	1100	1200
			Molar Quantities		
Phthalic Anhydride	3.0	.5	.5	—	—
Adipic Acid	—	2.5	2.5	3.0	3.0
Trimethylol propane	4.1	4.1	4.0	—	1.0
1,4–Butylene glycol	—	—	—	2.0	—
1,3–Butylene glycol	—	—	—	—	3.0
Hexanetriol	—	—	—	2.0	—

Table II

Physical Properties of Commercial Coatings

Coating Description	Dry through, hours	Hardness (1 week cure)	Gloss	Flexibility	Impact Resistance	Taber Index	Adhesion		
							Steel	Bonderized Steel	Aluminum
TDI–castor oil (4% Methyl diethanolamine)	2 5/6	34	96	P	P	12	F	P	F
MDI–castor oil (0.5% N–ethylmorpholine)	14 1/2	20	90	P	P	16	P	P	F
Polyisocyanate–polyester (highly branched having low molecular weight)	5	56	96	F	F	73	P	P	P
Polyisocyanate–polyester (low branching having high molecular weight)	2 2/3	36	87	F	F	24	P	P	F
Spar varnish (chinawood-phenolic type)	3	28	93	P	P	64	F	P	F
Alkyd (medium soya oil-phthalic anhydride type)	5 3/4	15	90	P	P	102	F	P	P
Oil-modified epoxy	7	12	82	P	P	55	F	P	F
Amine-cured epoxy	6 1/2	18	74	F	P	88	F	P	P

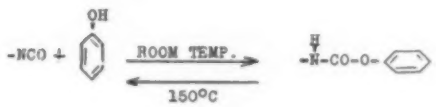
Description of Film Evaluation Testing Procedures

Test	Method	Substrate	Surface Preparation	Coating Application	Cure	Conditions
Dry Time	Fed. Spec. TT-P14 1 b 406.1	Glass	Alcoholic caustic; water-acetone	Cast 0.003" wet film 50% N.V.	Room Temp.	Reported as time in hours to dry through
Hardness	Sward Rocker	Glass	Alcoholic caustic; water-acetone	Cast 0.003" wet film 50% N.V.	1 wk. at Room Temp.	Reported as percent hardness, with reference to glass as 100%
Flexibility	Fed. Spec. 622.2 Conical Mandrel	Bonderite panels 6" x 10"	No additional treatment	Spray 25% N.V.	1 wk. at Room Temp.	Reported as passing or failing at ⅛" diameter
Impact Resistance	Variable Impact	Bonderite panels 6" x 10"	No additional treatment	Spray 25% N.V.	1 wk. at Room Temp.	Reported as passing or failing impact of two pounds dropped 14 inches against coated surface and against back of panel
Gloss	Fed. Spec. 610.1 Glossmeter	Bonderite panels 6" x 10"	No additional treatment	Spray 25% N.V.	1 wk. at Room Temp.	Reported as percentage reflectance with a 60° head
Abrasion Resistance	Fed. Spec. 619.2 Taber Abraser	Bonderite panels 4" x 4"	No additional treatment	Spray 25% N.V.	1 wk. at Room Temp.	Reported as Taber Index-mg. lost/1000 cycles; Wheel CS-17, 1000 gm. load, (panel abraded for 500 cycles)
Adhesion	Scotch Tape	Cold rolled steel and aluminum	Solvent wash with xylene	Cast 0.003" wet film 50% N.V.	1 wk. at Room Temp.	A small area of the coating is cross-hatched with knife cuts extending down to the substrate. Fail indicates coating adheres to Scotch tape which has been pressed onto the hatched area and torn off. Pass indicates continued adhesion to the substrate.
		Bonderite	No additional treatment			

Since isocyanate groups and hydroxyl groups start to react at an appreciable rate as soon as they are brought together, the practice is to keep the two separate until the coating composition is to be applied. If pigmented coatings are desired, the pigment is ground into the polyester. The coatings obtained from these isocyanate combinations possess unusually good resistance to abrasion and chemical attack.

To avoid the necessity of keeping the isocyanate and polyester in separate packages the Germans invented blocking technics. These are systems in which the activity of the isocyanate is blocked until it is desired to have the coating cure or set. The principle involves the reaction of the isocyanate group with agents that form complexes which are stable at room temperature but which decompose at elevated temperatures to liberate the isocyanate group. A typical example of a blocking agent is phenol, and the chemistry is as follows:

Blocked Isocyanates



Other blocking agents are malonic and acetoacetic esters, cyclohexanone oxime, succinimide, and certain secondary aromatic amines.

Coatings of this type are baking finishes. One of these blocked compositions is becoming of considerable industrial importance in this country as a wire enamel.

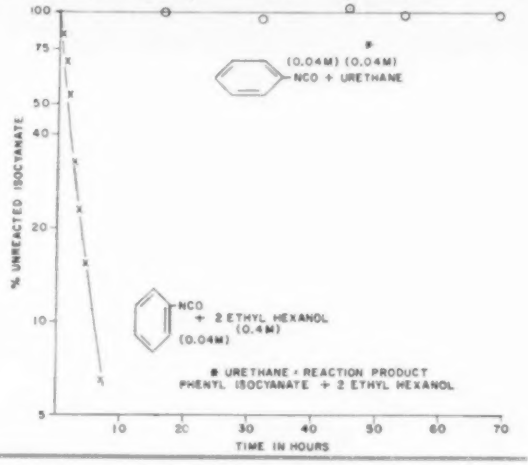
As already stated, isocyanates are noted for the fact that they are reactive with any substance containing active hydrogens. While this definition tends to read on itself, experience has shown that compounds containing "active hydrogens" include a wide variety of materials. However there are wide differences from class to class and compound to compound with respect to the rate at which reaction occurs with the isocyanate. For example, while OH groups are in general quite reactive, urethane groups are normally, for most practical purposes, essentially unreactive (Figure 1).

The curves shown here are for the simple cases of phenyl isocyanate with octyl alcohol (2-ethyl-1-hexanol) and with the corresponding urethane, showing that even in the case of these very simple molecules, isocyanates react only very slowly with urethane groups. In larger molecules especially where steric factors are more pronounced, the reaction with urethanes is even slower. Very useful examples of such compositions which contain both isocyanate groups and urethane groups, and therefore, by themselves are stable at room temperature, are the reaction products of tolylene diisocyanate (TDI)[1] and castor oil and diphenyl methane–4,4'–diisocyanate (MDI)[2] and castor oil.

These materials may be prepared by adding castor oil to the diisocyanate in solvent under a dry atmosphere and heating at 50-60°C. until the amine equivalent is 360-460 in the case of the tolylene diisocyanate (TDI) and 500-560 in the case of diphenyl methane diisocyanate (MDI). The reaction time is usually about one hour.

1. *National Aniline's Nacconate 80 (80% 2,4–tolylene diisocyanate and 20% 2,6–tolylene diisocyanate)*
2. *National Aniline's Nacconate 300*

Figure 1. Rate of reaction of phenylisocyanate with various reactive groups at room temperature.



Typical formulations are as follows:

	Parts by weight	
TDI	570	——
MDI	——	815
Castor Oil (anhydrous)	1000	1000
Xylene or toluene	1570	1815

In the absence of catalysts these products, dissolved in aromatic solvents, will remain essentially unchanged over many months. However, when tertiary amines, such as N–ethyl morpholine, N–methyl diethanolamine or ordinary cobalt and lead driers are added and the liquid is spread in thin layers, the film hardens in a matter of hours to yield surface coatings which possess unusual resistance to abrasion and chemical attack as well as excellent adhesion to most substrates.

The adduct formula above represents a ratio of three molecules of diisocyanate to one molecule of castor oil. Maximum Sward hardness is obtained at this ratio as illustrated in Figure 2. Optimum characteristics for other properties also occur at this molar ratio.

Other properties of clear coatings obtained using the three to one diisocyanate-castor oil ratio are shown in comparison with other coating systems in Table II.

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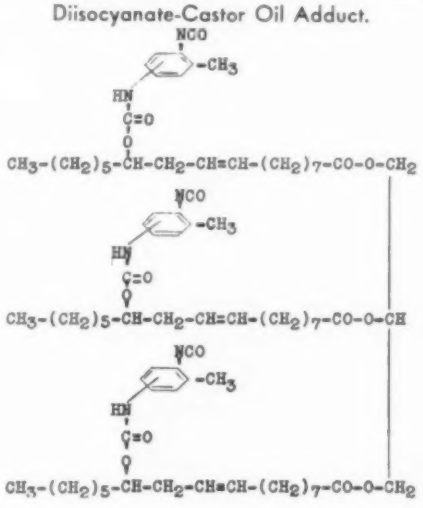
Diisocyanate-Castor Oil Adduct.



Polyethylene Films

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The first commercial polyethylene film was produced by the Visking Corporation in 1945. For several years there was one type of polyethylene film, and the main problem was to produce enough of it.

When the term "polyethylene" is used today it does not refer to one substance but to a whole family of aliphatic hydrocarbon resins which vary from about 0.914 to 0.960 in density. Commercial polyethylene resins available today fall roughly into three density groups as follows:

1. Conventional or low density types	0.914 to 0.925
2. Medium density types	0.93 to 0.94
3. High density types	0.95 to 0.96

These density differences are not very important in themselves. Their importance lies in the fact that they are the consequence of differences in molecular structure which determine marked differences in the physical properties of these resins. These differences in resin properties persist when the resins are extruded into films and, together with the extrusion variables, they determine the specific utility of the wide assortment of polyethylene films which are commercially available today.

It is one purpose of this paper to discuss briefly some of the basic properties of polyethylene films and to compare the principal types wherever possible. It is a further purpose of the paper to review some of the successful uses and indicated applications of these versatile polyethylene film properties.

Polyethylene Film Properties

The data used to illustrate this discussion are made up largely of typical examples obtained in our laboratories but should not be considered as necessarily defining or limiting in scope. New developments may and probably will change the picture in some of the details.

This paper was presented at the SPE Retec, "Polyethylene Properties and Uses", sponsored by the Cleveland-Akron Section.

Yield—Due to its chemical nature as an aliphatic hydrocarbon, polyethylene film containing no plasticizer or additives has a low density as compared with most other plastics. This is true of the high density type as well as the low. For example the conventional low density type polyethylene film will give a yield of 30,100 square inches per pound for a film 1 mil thick, while the high density type will show a corresponding value of 28,800 square inches per pound for 1 mil film. The cost implications of these facts are obvious.

Mechanical Strength—The tensile characteristics of the several types of polyethylene film are illustrated in Table I. The combination of adequate tensile strength and high elongation make for the toughness and general durability which characterize polyethylene films in their variety of packaging and other applications. The resistance to continued progression of a tear once started is important. Tensile strength tends to go up and elongation and tear strength down in the higher density types. This is in line with the observed increase in brittleness and greater stiffness in the high density films. The latter property is reflected in the values for stress at 10% elongation. Impact strength test methods are not yet fully standardized or fully defined. However, our own soft-ball drop test will give values of 2 to 4 feet for conventional polyethylene film 1.5 mils thick, whereas the medium and high density types will show 1 foot or less for this thickness.

The mechanical characteristics of polyethylene are retained to a useful degree down to temperatures of—70°F and lower. Furthermore, these properties suffer little or no deterioration on long storage at reasonable conditions or even on prolonged soil burial. One exception to this is that clear polyethylene film is subject to slow degradation on direct exposure to sunlight or certain ranges of ultraviolet radiation. This effect is counteracted to a high degree in properly formulated black polyethylene film.

Thermal Properties—Since polyethylene is a thermoplastic resin, polyethylene films are heat sealable. At the same time they have rather definite high temperature service limitations. The different density types differ progressively in these characteristics and Table II represents

Table I

Tensile Properties of Polyethylene Films (1.5 Mil Thickness)

TEST	Conventional Low Density	Medium Density	High Density
Tensile Strength MD	3,000	3,500	5,000
(lbs./sq. in.) TD	1,800	2,400	4,800
Elongation MD	275	225	300
(%) TD	450	75	10
Tear Strength MD	300	50	35
(grams/mil thickness) TD	175	300	400
Stress at 10% Elongation (lbs./sq. in.)	1,200	2,000	4,000

Table II

Thermal Properties in Relation to Density Type

Property	Conventional Low Density	Medium Density	High Density
Heat Distortion Temp. 66 lbs./sq. in (°F)	107–121	135	150–194
Vicat Softening Temp. (°F)	175–205	220–235	245–260
Heat Sealing Range (°F)	250–400	300–400	350–425

Table III

Permeability of Polyethylene Films to Gases and Vapors

GAS OR VAPOR	Conventional Low Density	Medium Density	High Density
Water*	1.4	0.7	0.3
Oxygen**	550	280	125
Carbon Dioxide**	2,900	990	580
Nitrogen**	180	—	42
Sulphur Dioxide**	6,200	—	—
Ethylene Oxide**	29,300	—	—
Methyl Bromide**	79,100	—	—

* grams/100 sq. in./24 hrs./mil

** cc./100 sq. in./24 hrs./mil

Table IV

Optical Properties of Polyethylene Films

PROPERTY	Conventional Low Density	Medium Density	High Density
% Haze	6–30	8–11	30–85
% Gloss (45°)	15–60	40–55	3–20
Visual Transparency (Inches at which eye chart can be read)	2–2644	150–250	0–32

an attempt to assemble from the trade literature and our own experience some of these pertinent properties.

Inertness—All of the polyethylene films show a high degree of chemical inertness to most corrosive chemicals and solvents. The medium and high density types show this to an even higher degree than the conventional types. The only common solvents which affect even the low density types of polyethylene films are chlorinated hydrocarbons and aliphatic and aromatic hydrocarbons. At room temperature these solvents only swell the material but do not dissolve it. At higher temperatures the polyethylene film will dissolve in some of these solvents but on cooling, the material deposits as a microcrystalline powder. For these reasons, solvent sealing is not a practical method for fabricating polyethylene films.

The chemical and physical inertness of the polyethylene hydrocarbon makes for poor adhesion of printing inks and adhesives. This difficulty can be overcome by electronic, flame or chemical surface treatment techniques which render the surface more polar in character. Much of the commercial polyethylene film today is so treated. The newer medium and high density types also accept such treatments.

Polyethylene films are also practically inert biologically. They are odorless, tasteless, non-toxic and resistant to micro-organisms.

Permeability—Although polyethylene films are generally resistant to chemicals some of them are rather highly permeable to many gases and vapors. The medium and high density types of films tend to show progressively less permeability than the conventional types. Table III shows some of these relationships using some of our own data and some from the trade literature. While it is dangerous to generalize, it is a fairly safe rule-of-thumb to consider that medium density film will show $\frac{1}{2}$ to $\frac{1}{3}$ and high density polyethylene $\frac{1}{4}$ to 1/5 the permeability of the low density types. A somewhat similar relationship appears to hold true for penetration of the films by oils, essential oils and related liquids, but the difference between the high and low density types is often greater than the fractions indicated above.

Optical Properties—The optical properties of polyethylene films vary through a wide range even within a density type, depending on the specific resin and production conditions employed. Fortunately, this is to a large extent controllable so that it is possible to select the optical properties required provided they are not tied up with extremes of other incompatible characteristics. Table IV illustrates broadly the range of several optical properties which are available in the several density types. The medium density films are relatively clear while the high density ones are rather cloudy.

The high clarity, conventional density films tend to have a very smooth and relatively tacky surface and therefore show poor slip and blocking characteristics. This is generally corrected by use of very small amounts of slip or anti-blocking additives. Medium and high density polyethylene films usually do not require this because their added stiffness tends to compensate for any poor slip or blocking tendencies.

Polyethylene Film Uses

The preceding section of this paper may be summarized by saying that polyethylene film in its many types offers to the packaging, building, agricultural, industrial and other fields the following set of qualities:

1. It is tasteless, odorless and non-toxic.
2. It is chemically and biologically inert.
3. It is cheap.
4. It has good strength and toughness.
5. It retains its useful properties on exposure to very low temperatures and, in some of its types, to fairly high temperatures for long periods of time.
6. It is readily heat sealable and printable on high speed equipment.
7. It is an excellent moisture and moisture vapor barrier.
8. It is readily permeable to gases such as oxygen and carbon dioxide as well as many organic vapors.
9. It is available in thicknesses up to 20 mils, in widths up to 32 feet in almost any length that may be desired.

Now let us see how these qualities have been or may be put to use in a practical manner. Most of these examples

relate to the conventional, low density type since these are well established. It is too early to predict the ultimate success of specific applications of the medium and high density polyethylene films since most of these are still in the market research or field evaluation stage.

Packaging Applications

A. Food Packaging

1. One of the best known examples is the packaging of fresh produce such as carrots, potatoes, radishes, apples, citrus fruits, and the like. The toughness and high impact durability, particularly when in contact with water and ice, are prime requirements. High permeability to oxygen and carbon dioxide are helpful but even this is augmented by controlled perforation. Clarity and sparkle are becoming increasingly important in this use.
2. Packaging of candy of various types is a good example of use of polyethylene film to protect a dry hygroscopic food product against pick-up of moisture.
3. The use of polyethylene film on frozen poultry makes good use of its moisture protective qualities as well as the good durability at low temperatures.
4. The recent interest in "boil-bag" food packaging should prove to be a good outlet for the medium or possibly the high density types of film which are resistant to boiling water temperatures. Either a fresh or frozen food may be packaged in the film and later cooked in the bag by dropping it in boiling water.

B. Packaging Pharmaceutical or Surgical Supplies
This is taking two forms, one using conventional polyethylene on items to be sterilized by irradiation techniques and the other using high density polyethylene film for products, such as bandages, which are to be sterilized in steam autoclaves.

C. Soft-goods Packaging
This field has grown rapidly since the development of the high clarity and slightly stiffer types of polyethylene film and has become common for shirts, pillow cases, and sheets.

D. Hardware and Notions Packaging
These uses require primarily the toughness and puncture resistance of the film with clarity and sparkle as desirable features.

Building Trades Uses

A. Moisture Barrier Under Concrete Slabs
This well established use requires the moisture impermeability, the general toughness, the long-time durability and the economics of polyethylene film.
The same is true of its use as a moisture barrier for foundation walls.

B. Concrete Curing Blanket
This use has become common in highway and other concrete construction. It makes use of the excellent moisture retention qualities combined with toughness and durability in spite of light weight. Stronger concrete has resulted from this use.

C. Moisture Vapor Barrier in Side Walls, Ceiling and Under Flooring
Applied to the warm side of such wall construction, polyethylene film offers ease of application, good protection against moisture and dust.

D. Temporary Covering for Building Openings
This permits working in daylight without heavy overclothing in cold weather and greatly extends the construction season in many cases.

E. General Purpose Tarpaulin Uses
The black polyethylene film finds many uses in covering all sorts of construction supplies against inclement weather. Cost, outdoor durability of the black film, flexibility and toughness are essential factors here.

Agricultural Applications

A. Silo Covers
Black polyethylene film is finding rapid acceptance as a cover for stack and trench type silos in making high quality grass silage. Obviously, good outdoor durability, low moisture vapor transmission and proper gas transmission characteristics are the requirements which in addition to economics are most important in this use.

B. Soil Mulching Application
Black polyethylene film is finding interesting use as a ground cover or mulch for such crops as strawberries, pineapples and many truck crops. By conserving soil moisture and preventing weed growth, such film greatly minimizes cultivation requirements and also helps to keep the produce clean in the field.

C. Greenhouse Construction
Clear polyethylene film has proven to be an effective material for the construction of low-cost greenhouses on simple wooden frames. The high light transmission properties plus surprising resistance to the effects of hail, sleet, rain and snow, make this application practical.

Industrial Uses

A. Automobile Seat Covers
Everyone is familiar with the temporary seat covers on most of the new automobiles they have purchased in recent years. Polyethylene film has satisfied this market because it offers the required toughness combined with good appearance at a low price.

B. Rubber Separator Uses
Polyethylene film, both in smooth and embossed form, has proven to be an effective replacement of Holland Cloth to protect and separate gum stock surfaces prior to their being built into tires and related products.

C. Display Pennants
Everyone is familiar with the plastic pennants so prominently displayed in our gasoline service stations. This use illustrates the versatile colors available in polyethylene film as well as its general strength and toughness properties.

D. Stratosphere Balloons
Finally, in this "Geophysical Year" we cannot refrain from mentioning the scientifically important use of polyethylene film in constructing the stratosphere balloons which are such a vital factor in seeking out the mysteries of the upper-atmospheric regions. This requires the extremes of lightness, toughness, resistance to low temperatures and dependable structural uniformity over large areas which properly fabricated polyethylene film offers to the highest degree. ★★

VINYL COMPOUNDS FOR EXTRUSION

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Vinyl compounds—whether they are flexible or rigid—are well suited to fabrication by the extrusion process. This suitability has resulted from the research and development work done on the vinyl resins since their inception and first commercial production in the mid-thirties. It is in this field of research and development that the material supplier makes one of his largest contributions to the progress of the art of plastic extrusion.

Vinyl resins in their raw form are white flourlike materials which can be fused under heat and pressure to give a hard, tough material. These resins are compounded with plasticizers, stabilizers, fillers, lubricants and pigments to achieve compounds having the desired balance of properties to meet the needs of commercially extrudable materials. The fact that a balance must be achieved among all of the components of an extrusion compound makes it necessary to accumulate a great deal of technological information on production, mixing, compounding and fabrication. The science of formulating these hard resins into materials capable of fulfilling such applications as garden hose, electrical insulation, belting, pipe, upholstery welting and gasketing is being constantly explored at the laboratories of the materials suppliers.

Addition of Plasticizers

Vinyl resins are mixed with other components to obtain compounds for specific end uses. The addition of plasticizers to the vinyl resins produces the greatest change in the resin and normally constitutes 30 to 40 per cent by weight of the compound. It has been stated that over 100 plasticizers are in use commercially in the vinyl plastics industry. With this variety of plasticizers alone, the need for test equipment and personnel to evaluate them can be readily seen. The plasticizers can be classified as ester, polymeric, epoxy and extender types. The ester types are the most widely used. The esters include phthalates, phosphates, sebacates, adipates and azelates; the polymeric types are viscous resinous materials typified by such plasticizers as "Paraplex" G-25 and Flexol Plasticizer R-2H. They show superior resistance to extraction and are essentially non-volatile. The epoxy type plasticizers exhibit stabilizing characteristics on a vinyl compound, as well as having plasticizing efficiency. This type of plasticizer is characterized by "Paraplex" G-60 and G-62. The extender types are based on petroleum by-products, chlorinated paraffins and other lower cost materials which are compatible when used in conjunction with a primary type plasticizer.

Plasticizer Systems

Of the ester type group, the phthalates account for approximately 68 per cent, phosphates for 20 per cent, while the low-temperature plasticizers based on the sebacates, adipates and azelates, etc., constitute about 12 per cent. Di-2-ethylhexyl phthalate is probably the most widely used of the phthalate-type plasticizers, because it typifies all the good properties to be obtained from phthalates. The phthalates are compatible in high percentages, impart good flexibility with generally satisfactory low-temperature characteristics, a low odor level and good clarity. The phosphates are used primarily where flame resistance is of major importance. However, they also have very effective solvating actions on vinyl resins and sometimes are used to improve the handling characteristics of compounds.

The next material which is used in compounding vinyls is a stabilizer or stabilizer system, to prevent or retard the degradation of the vinyl resin by heat and light. These materials are used in much smaller percentages and effect very little change in the physical characteristics of the vinyl compound. There are essentially five classes, the lead salts constituting the most important. Lead salts range in price from 20c to 50c per pound and are used in opaque compounds where the material will not come in intimate contact with food or food products. The second class of stabilizers is those based on the tin salts. These stabilizers are quite expensive and light stability must be obtained in transparent materials. The third class is the organic compounds of barium and cadmium. Similar to the tin salts in effect, they are used when economy is the predominant concern. They range in price from 60c to 90c per pound. The epoxy-type combination plasticizer-stabilizer constitute the fourth class and range in price from 30c to 35c. These may be used with compounds coming in contact with food products. The fifth class con-

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sists of those based on a mixture of calcium, magnesium, and zinc compounds which may be used in compounds coming into contact with food products. The price of this type of stabilizer is 30c to 50c per pound.

Lubricants are used in vinyl compounds to improve the release characteristics of the materials during extrusion or fabrication. Generally, the quantity of lubricant used is in the neighborhood of one per cent. In certain instances, a lubricant is not necessary since some of the other constituents may provide sufficient lubricity for normal handling.

The Coloring Materials

The colorants used in vinyls are based on inorganic and organic pigments. These materials run anywhere from 50c to $5.00 per pound for the cadmium type pigments. It is important that the pigments be of high purity when used in compounds for electrical insulation. The same pigments can be used in contour and electrical insulation compounds where the degree of purity is determined by the application for which the end products is intended.

Fillers are the last major material used in compounding with vinyl. These fillers are used to provide specific properties, as well as to make the final product more economical. Fillers improve extrusion characteristics and impart improved electrical properties to certain electrical insulating compounds. The two main classes of fillers are the clays and calcium carbonates. Only the calcined clays are used because of the tendency shown by the natural clays to produce color changes during fabrication or weathering. Clays are priced in the range of 2c to 3c per pound. The calcium carbonate type of filler can be either the natural at 1c to 2c per pound or the synthetic at 6c to 8c per pound. The synthetic calcium carbonates do not have the high degree of ionic purity necessary for use in electrical insulating compounds. In this particular instance, nature has outdone science in producing a purer material.

Typical Formulations

Formulations for two typical transparent materials and two opaque materials appear in Table I. These are plasticized materials and the two clear compounds are used as garden hose and general-purpose clear belting and tubing material. In the opaque category is shown a general-purpose, high-gloss material having a Durometer hardness of about 70, and a material developed specifically for use with food. The components of each formulation are carefully chosen for the specific properties they impart to the final product.

In the garden hose type you will note that the plasticizer is based on two materials—plasticizer DOP and DOA. The addition of 7½ parts of the plasticizer A-26 imparts superior low-temperature properties to the compound since it is an azelate plasticizer. There are two stabilizers used of the tin salts class in order to achieve transparency, with the bulk of it being D-22. A small percentage of D-15 is added for improved heat stability during processing and, also, to act as a mild lubricant during compounding. The general-purpose clear is plasticized solely with DOP and contains one-half of one per cent lubricant. A very small percentage of colorant may be used when the article being fabricated is required to have a special tint as in this example. One of the opaque compounds, the general-purpose high-gloss, is again based on the DOP plasticizer, but here, because of the opacity, a lead stabilizer can be employed. In order to obtain the high gloss, a filler of very small particle size is used. One per cent of lubricant is added to overcome the dryness imparted by the filler. The colorant is of a somewhat higher loading than usual in a transparent material because of the necessity to overcome the whiteness imparted by the filler. The compound designed for food usage is based on B-16 plasticizer which is one of the phosphate types approved for use in applications where the compound may come into contact with food or food products. The lead or tin stabilizers have not been used because they lack F.D.A. clearance for use in this way. Calcium stearate and an epoxy type stabilizer are used in a mixture. The lubricant in this particular case is a wax, and both it and the colorant have been cleared by the Pure Food and Drug Administration.

In addition to the formulations shown in Table I, special formulations have been developed for wire and cable where the amount of plasticizer has been reduced to the bare minimum in order to improve the resistance to cutting and abrasion so often encountered in thin-wall insulations. These materials are designated as semi-rigid and are utilized for thin-wall insulation primarily. Finished conductors insulated with semi-rigid materials are used in switchboard cables and intercommunication cables.

Table I
Formulations For Some Typical Vinyl Compounds

	CLEAR	
MATERIAL	Garden Hose Type %	General-Purpose %
Vinyl Resin (VYNW)	66.8	71.0
FLEXOL Plasticizer (DOP)	23.8	26.5
FLEXOL Plasticizer A-26 (DOA)	7.5	---
Tin Stabilizer (D-22)	1.5	2.0
Tin Stabilizer (D-15)	0.2	---
Lubricant	---	0.5
Colorant	0.2	As necessary
	100.0	100.0

	OPAQUE	
MATERIAL	General-Purpose High-Gloss %	Food Usage %
Vinyl Resin (VYNW)	51.0	56.5
FLEXOL Plasticizer (DOP)	34.0	---
B-16 Plasticizer	---	26.5
Lead Stabilizer	2.0	---
Calcium Stearate and Epoxy-type Stabilizer	---	3.5
Filler	10.0	10.0
Lubricant	1.0	1.0
Colorant	2.0	2.5
	100.0	100.0

Rigid vinyl compounds are based on essentially 100 per cent vinyl resin. These resins are stabilized with special organic tin stabilizers and usually contain an adequate quantity of wax or other lubricant. A typical formulation for an unmodified rigid polyvinyl chloride compound would be 96 per cent resin, 3 per cent stabilizer and 1 per cent lubricant. A second class of rigid extrusion compound is made which is called "impact" polyvinyl chloride, and in this compound a portion of the resin has been replaced with Buna-N-resin to improve the impact resistance. ★★

Experience with Oil Field Extruded Plastic Pipe in 1955

Report of Technical Unit Committee T-1J on Oil Field Structural Plastics, National Association of Corrosion Engineers.

IN LATE 1955 NACE Technical Unit Committee T-1J undertook a study of current oil field experience with extruded plastic pipe. For non-users of plastic pipe the questionnaire was designed to find out what data they might need to aid them in utilizing this material. It was decided to gather this data through a questionnaire survey of oil industry members of NACE and Non-NACE members who were known to be prominent users of extruded plastic pipe. The questionnaire was prepared, and after considerable review, was mailed in mid 1956 to about 250 individuals associated with oil production operations.

This report presents the results of this survey. Most questionnaire returns were received in August 1956; therefore, the results reported here should cover experience between the installation date in 1955 until August 1956. This ranged from 8 to 20 months.

Fifty-six replies were received. Sixteen were from independent producers while 40 were from six major producers. Seven major companies cooperated by forwarding replies to cover all of their United States operations.

Summary

1. The data gathered by this questionnaire revealed several operators used considerable footage of extruded plastic pipe in 1955 with no failures to date. These operators reported using extruded plastic pipe as a routine matter in low pressure service. In some cases this amounted to considerable footages. For instance, fifteen operators, who reported using extruded plastic pipe in low pressure service, used 668,005 feet in 1955 with no failures at the time of answering this questionnaire. The five largest users in 1955 laid 585,549 feet of pipe without a failure at the time of reporting.
2. Nine smaller operators, who use the pipe in low pressure service, reported twenty-two failures in 145,286+ feet of 1955 pipe installations. This is equivalent to one failure in slightly less than every 7,000 feet of pipe.
3. Users classified as testing extruded plastic pipe did not fare so well however. Although seven operators used 30,370+ feet without failure, eight other operators experienced over 34 failures in about 28,800+ feet of pipe. This is equivalent to one failure every 400 feet of pipe. Analyses of the reports on 30 of the 34 failures indicated the pipe could have been under conditions of low safety factor.
4. Thirty-six operators, who used 850,000 feet of extruded plastic pipe in 1955, reported installation cost data of plastic and competitive pipe. The average data indicate plastic is somewhat cheaper to install, although certain special conditions alter this situation. Twenty operators (using 682,000 feet of pipe) reported plastic less expensive to install; sixteen operators (using 174,000 feet of pipe) reported it to be more expensive than other types.
5. Data desired most by small or non-users of extruded plastic pipe are physical properties and installation costs.

Discussion

The breakdown of extruded plastic pipe users, test users, and non-users in 1955 is shown in Table 1. The number of installations by type of service is shown in Table 2. The amount of pipe by type of service is shown in Table 3. The pipe footage covered by the questionnaire according to type of material is shown in Table 4. Polyvinyl chloride pipe includes both types since many of the persons

TABLE 1—Type of Extruded Plastic Pipe User

Type of User	Number of Independent Operators	Number of Major Companies	Total
Routine User	10	14	24
Test User	1	16	17
Non-User	5	10	15
Total	16	40	56

TABLE 2—Number of Extruded Plastic Pipe Installations by Type of Service

Type of Service	NUMBER OF INSTALLATIONS					
	Independent Operators		Major Companies		Total	
	Routine User	Test User	Routine User	Test User	Routine User	Test User
Low Pressure Flow Lines	143	..	94	23	237	23
Salt Water Systems	49	..	122	9	171	9
Gas	41	..	...	2	41	2
Other	..	1	8	6	8	7
Total	233	1	224	40	457	41
					Total 498	

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TABLE 3—Amount of Extruded Plastic Pipe by Type of Service

Type of Service	FOOTAGE OF PIPE					
	Independent Operators		Major Companies		Total	
	Routine User	Test User	Routine User	Test User	Routine User	Test User
Low Pressure Flow Lines	236,515	....	171,141	32,901	407,656	32,901
Salt Water Systems	148,856	....	189,540	18,177	338,396	18,177
Gas	63,149	....	.....	4,900	63,149	4,900
Other	.....	1,000+	4,090	140+	4,090	1,140+
Total	448,520	1,000+	364,771	56,118+	813,291	57,118+
					Total 870,409+ feet	

Note: The plus sign represents pipe under evaluation by test users who did not report exact footage.

TABLE 4—Amount of Extruded Plastic Pipe by Type of Material

Pipe Material	FOOTAGE OF PIPE					
	Independent Operators		Major Companies		Total	
	Routine User	Test User	Routine User	Test User	Routine User	Test User
Butyrate	176,586	....	102,680	13,261	279,266	13,261
Styrene Copolymer	43,600	1,000+	186,801	22,790	230,401	23,760
PVC	170,334	....	71,240	20,097+	241,574	20,097
Not Identified	58,000	....	4,050	....	62,050	.....
Total	318,520	1,000+	364,771	43,151+	813,291	57,118+
					Total: 870,409+ feet	

Note: The plus sign represents pipe under evaluation by test users who did not report exact footage or type plastic.

TABLE 5—Failure Frequency According to Number of Routine Users, Number of Failures and Pipe Footage

	Independent Operators	Major Companies	Total
Number of Users Having No Failures	8	7	15
Pipe Footage Used with No Failures	428,435	239,570	668,005
Number of Users Having Failures	2	7	9
Number of Failures Experienced	5	17	22
Pipe Footage of Users Having Failures	20,085+	125,201+	145,286+

Note: Plus sign represents pipe under evaluation by test users who did not report exact footage.

TABLE 6—Failure Frequency According to Number of Test Users, Number of Failures and Pipe Footage

	Independent Operators	Major Companies
No. of Users Having No Failures	0	7
Pipe Footage Used with No Failures	0	30,370+
No. of Users Having Failures	1	8
No. of Failures Experienced	Several	34+ Several[1]
Pipe Footage of Users Having Failures	1,000	12,781+

[1] One operator reported several failures in each of two installations.
Plus sign represents pipe under evaluation by test users who did not report exact footage.

TABLE 7—Success in Operating Without Further Leaks According to Type of User

	Independent Operators		Major Companies	
	Routine Users	Test Users	Routine Users	Test Users
Number of Users Experiencing Failures	2	1	7	8
Number of Failures Experienced	5	Several	17	34+ Several[1]
Number of Users Making Successful Repairs	1	0	7	3
Number of Users Experiencing Additional Failures	1	1	0	6
Number of Failures Experienced by Users Having Repair Difficulty	1	Several	0	28+ Several[1]

[1] One operator reported difficulty in repairing several failures in each of two systems.

questioned were unsure of the type they had used.

An independent operator reported the largest footage use by one operator of 206,500 feet. Of this approximately 162,300 feet were PVC and 44,200 feet were butyrate pipe. An independent also was the second largest consumer. This operator reported using 130,000 feet of which 90,000 was butyrate and 40,000 was styrene copolymer.

A major company reported the third largest footage use in 1955 of all companies reporting. That company used 110,000 feet of which approximately 59,200 feet were styrene copolymer, 45,000 feet were butyrate and 4,800 feet were PVC.

The fourth largest user of those reporting was an independent operator who used 56,000 feet, most of which was not identified. Fifth largest extruded plastic pipe consumer was a major company which used 19,000 feet, principally styrene copolymer and about 6,000 feet of butyrate.

Failure Experience

Failure experience of those operators who used extruded pipe on a routine basis is shown in Table 5. Fifteen operators used almost 700,000 feet of pipe without a failure. Nine operators, using 145,000 feet of extruded plastic pipe, experienced 21 failures. Among the latter group this is approximately one failure for every 7,000 feet of pipe used. For the complete group of routine users the failure frequency was approximately one per 39,000 feet of pipe.

The failure experience of those users who were testing extruded plastic pipe in 1955 is shown in Table 6. The 1,000 foot line installed by the independent operator, which experienced several failures, cannot be regarded as representative. The line was in a severe underwater service clamped to a weighted cable in a way to permit several types of stresses of unknown magnitudes. Seven major companies tested more than 30,000 feet of pipe without a failure. However, eight other operators experienced 34+ failures. Thirty of these were encountered by three operators, only one of whom reported the amount of pipe he tested. An analysis of these reports revealed one operator (experiencing seven failures) was operating a pipe thought to be polyethylene at a stress of approximately 900 psi at 90 F. The apparent reason for failure was reported as poor installation methods.

Another operator, who experienced six failures, reported data indicating failures occurred under the following conditions. To styrene copolymer pipe operating at stresses of 170-400 psi with a tem-

perature of 90-95 F; to PVC pipe operating at a stress of about 270 psi at 90 F; and to butyrate pipe operating at a stress of 400 psi and 90 F.

The third operator, who experienced 17 failures on 8,800 feet of pipe, reported the failures occurred to styrene copolymer pipe at conditions amounting to a stress of about 670 psi and 105 F. In the cases of the last two operators the pipe wall thicknesses were not reported; standard weight thicknesses were used in calculating the reported stresses. The stresses would have been much higher of course if the pipe was actually thinner wall such as SWP.

The operator reporting several failures in each of two systems (see note on Table 6) was operating styrene copolymer pipe at a stress of about 550 psi and 80 F.

From this combination of actual and conservatively estimated stresses it appears that a large number of these failures occurred under conditions of very low safety factors. Thus, any pipe imperfections, or additional stresses of installation could easily cause a stress higher than the long term strength of the resin resulting in a failure.

Table 7 shows the success obtained by the various operators in repairing leaks. Six of the eight major companies reporting failures also had difficulty in operating without further difficulty. Four of these six operators were the same group mentioned above who were operating under conditions of low safety factor. The cause for further failures by the other two operators experiencing additional difficulty was not apparent from the reported data.

Table 8 summarizes the cause attributed by the operator to the failure of his plastic pipe. The largest number of failures occurred among the major operators who were testing the pipe. Only seven failures were attributed to excessive pressure, whereas earlier in the report one operator reported seven failures with a material thought to be polyethylene operating at a stress of 900 psi at 90 F, and another reported 17 failures with styrene copolymer operating at a stress of 670 psi and 105 F. Yet only four of these 24 failures were thought by the operators to be due to excessive pressure. This suggests these operators might not have been familiar with stress limitations of extruded plastic pipe, and might have felt the failures must be due to something other than the strength properties.

Poor glue joints and poor installation can, of course, be corrected with installation experience. Impact failures fall in the category

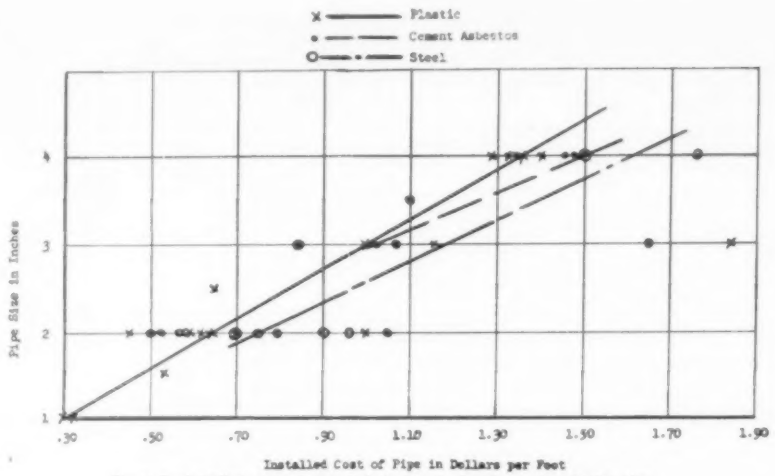

Figure 1—Installed costs of extruded plastic, steel and cement asbestos pipe.

TABLE 8—Cause of Failure as Evaluated by Operator

Cause of Failure	Independent Operators		Major Companies		
	Routine User	Test User	Routine User	Test User	Total
Excessive Pressure	0	0	0	6	6
Excessive Temperature	1	0	0	0	1
Poor Glue Joints	1	0	12	7	20
Poor Installation	1	0	1	4	6
Impact	1	0	0	2	3
Faulty Pipe	0	0	2	2	4
Other	1	Several	2	13+	16+
Total	5	Several	17	34+	56+

Note: Plus signs represent failures experienced by users who did not report the exact cause of failure.

TABLE 9—Distribution of Pipe Footage Used and Failures Experienced When Grouped by Fives From Largest to Smallest Pipe User

User Classification According to Amount of Pipe Used in 1955	Routine Users		Test Users	
	Footage	Failures	Footage	Failures
Top Five Largest Users of Pipe	585,549	0		
Second Five Largest Users of Pipe	150,005	6	20,000	0
Third Five Largest Users of Pipe	35,101	10	21,967	4+
Fourth Five Largest Users of Pipe	27,940	3		
Fifth Five Largest Users of Pipe	8,030	0	12,111	1
Sixth Five Largest Users of Pipe	5,510	3	2,920	+
Eleventh Smallest Users of Pipe	1,156	0	120+	29
Total	813,291	22	57,118+	34+
	Total Footage 870,409+			

TABLE 10—Identification of Failures by Type of Material, Location of Failure, and Part Failing

Identification of Failure	Number of Failures	
	Independent Operators	Major Companies
By Material:		
Butyrate	4	11
Styrene Copolymer	Several	25+
PVC		6
Unknown	1	7
Total	5+	49+
By Location:		
Above Ground	0	4
Buried	5+	45+
Total	5+	49+
By Part:		
Pipe Body	3+	23+
Coupling	1	22
Plastic-Metal Adapter	1	4
Total	5+	49+
Total Failures by Group	5+	51+

TABLE 11—Economics of Plastic Pipe Installations

Question: Can Plastic Pipe Be Installed Cheaper Than Pipe It Replaces	Answer: By Numbers of Operators				
	Independent Operators		Major Operators		
	Routine User	Test User	Routine User	Test User	Total
Answers:					
Yes	8		8	4	20
No	1		5	10	16
Equal	—		—	1	1
Depends on Situation	1		—	1	2
Total Operators Answering Question	10	0	13	16	39
Total Operators in Class	10	1	14	16	41

TABLE 12—Extruded Plastic Pipe Usage in Feet Versus Economics of Plastic Pipe by Operators

	Independent Operators		Major Companies		
	Routine Users	Test Users	Routine Users	Test Users	Total
No. of operators feeling plastic pipe cheaper than pipe it replaces	8	—	8	4	20
Plastic pipe footage used by above operators	379,290		274,990	28,450+	682,730+
No. of operators feeling plastic pipe more costly than other pipe	1	—	5	10	16
Plastic pipe footage used by latter operator	65,000		83,231	25,748+	173,979+

TABLE 13—Reported Reason for Using Extruded Plastic Pipe

Reason for Plastic Pipe	Number of Operators			
	Independent Operators		Major Companies	
	Routine Users	Test Users	Routine Users	Test Users
Corrosion Control	6	1	10	13
Paraffin Control	4	—	6	9
Flow Characteristics	2	—	2	1
Other			1	2

Note: Some operators reported duplicate reasons; others did not report a reason.

TABLE 14—Reasons for Not Using Extruded Plastic Pipe by Small and Non-Users

Reason	Number of Operators	
	Independent Operators	Major Companies
No field experience	2	7
No low pressure applications	2	14
Poor previous results	1	8
No contractor experienced	1	0
Insufficient physical data	3	12
Little cost savings possible	4	19
Other	2	2
Testing where appropriate	0	1

TABLE 15—Information Desired by Non-Users or Small Users of Extruded Plastic Pipe

Information Desired	Number of Operators	
	Independent Operators	Major Companies
Operation data on previous installations	6	19
Operating pressures for established and published safety factors	6	20
Installation costs	4	13
Other	2	3

of operating technique which also is gained by experience. Only four failures were attributed to faulty pipe. Ten of the sixteen failures classified as due to other causes were said to be by split joints. Two failures classified due to other causes occurred to a butyrate installation operating above ground at 104 F.

An interesting aspect of the reported failures is the distribution of failures according to amount of pipe used. Table 9 is a summary of failures by users from largest to smallest after grouping the users by fives. These data roughly indicate 1955 failures are inversely proportional to the amount of pipe used during that year. It could also mean that the large users have had sufficient experience in previous years to enable them to use considerable footage in 1955 with few failures. Table 9, as well as Tables 5 and 6, indicate test users have a higher failure rate than those who use extruded plastic pipe as a routine matter in low pressure service.

Table 10 summarizes the failures by type of materials, location of pipe at the failure, and part of the pipe system experiencing the failure.

Costs

Table 11 shows a breakdown of how 41 operators felt about the installed cost of extruded plastic pipe versus other types of pipe. Thirty-eight of the 41 routine or test users expressed an opinion on their questionnaire. Table 12 illustrates the amount of pipe used by the 36 operators who definitely felt one way or the other on the question.

Nineteen of the 20 operators, who felt plastic pipe was less expensive to install than other pipe, reported cost figures. Figure 1 is a plot of pipe size versus the reported costs to install extruded plastic, steel, or cement asbestos pipe. This is a composite plot of all data reported with weighted average lines drawn in to indicate the average cost of the various types of pipe. The data reported indicate the average cost to install extruded plastic is slightly less than cement asbestos in the 3 and 4 inch sizes, and is less than steel pipe in the 2 to 4 inch size range.

Purpose of Plastic Pipe

The questionnaire sought to determine the reason various operators used extruded pipe. A summary of the replies is shown in Table 13. Many operators reported duplicate reasons; others did not report any. Although the questionnaire did not inquire as to the suc-

(Please turn to page 70)

Edited by **Louis Paggi**, *Consultant, E. I. du Pont de Nemours & Co., Inc.*

Testing Molded Articles

A. C. Webber

Senior Supervisor, Research Div., E. I. du Pont de Nemours & Co., Inc.

Unfortunately there is not, nor can there be, a general series of tests suitable for all pertinent properties of all molded articles. There are many standard methods by which you can test the identity and quality of your raw material but most tests for your products must be designed to order for each particular molding. On the other hand there are a few general principles which may help you to select or devise appropriate tests and to avoid overlooking important properties.

Consideration of some of the problems in evaluation of appearance, strength and permanence of molded articles may serve to illustrate these principles.

1. Appearance

It is probably true that the first test your product must pass is one of its appearance. If your customer doesn't like the way it looks, he will probably test it no further. Assuming that the part is the intended shape and size, the two most important attributes of appearance are color and surface quality. If a simple visual test does not suffice, you may use objective methods for color measurement. Fortunately, this science has reached the point where instruments and methods exist which equal the sensitivity and exceed the reliability of the human eye. If you use your eyes for this test, however, remember that the observed color depends, in addition to the physical nature of the object, (1) upon the nature of the light used to illuminate it and (2) upon the eyes used to see it. Thus, for all color comparisons, north sky light or a standard lamp (usually called Illuminant C) should be used and at least two observers should make comparisons with a suitable standard.

The grosser aspects of surface quality are obvious but the glossiness of the surface is a very complex property. Either carefully specified viewing conditions must be used visually or a standard gloss measurement agreed upon between you and your customer. Instruments and methods suitable for any part which has a flat surface of at least 1 sq. in. are available.

II. Strength

If the appearance of the molded object is satisfactory, we must next be sure that it is strong enough to do what is expected of it. For testing against strength requirements, standard materials test methods will only help you in principle. We must devise actual techniques suitable for the part and the function. The principles recognized in materials testing must be kept in mind. For example, strength properties of plastics change with temperature and rate of stressing, sometimes gradually but often suddenly. A part which is tough enough for its job at room temperature may be too brittle at low temperatures. It may be stiff enough at 180°F. but far too limp at 200°F. An object which could sustain a heavy static load indefinitely might shatter to bits under a hammer blow. While you will have avoided gross misapplications in your original choice of material, it is surprising to the uninitiated how the properties of the material may vary with fabrication. A change of 10°C. in cylinder temperature may cause a change of 600% in impact strength of the molded part. A few degrees variation in temperature may be the cause of large differences in stiffness. Improperly conditioned molding powder may make brittle parts of otherwise satisfactory appearance. It is these hidden variations in properties due usually to fabrication variables which you will want to detect. The following general principles are the ones most often needed.

A. If the Stiffness of the Product is Important

As a general rule for small deformations under a fixed load, the amount of bending, twisting, or stretching measures the stiffness of the object. A simple system can be devised for practically any object so that the deflection corresponding to a fixed load can be measured. The converse is just as valid but usually less convenient.

B. If Toughness is Important

Test the part to destruction by a loading simulating the intended use. Remember that most materials are rate sensitive-don't use a hammer blow to test a part which will never normally need high-speed impact, or be satisfied yourself with deforming the object slowly in a vise when it must withstand impact. Of course, it is equally wrong, but not uncommon, to do either of these things to a part which is destined to lead a completely protected life.

The human animal is not nearly as dependable a loading device as gravitational force. Hence the popularity of drop tests where the part may be dropped from a fixed height or a ball or another object dropped on the part to test its toughness.

In all toughness testing, it must be remembered that we are dealing with a statistical population, hopefully normal. Hence the accuracy with which this property is measured is a function of the number of parts tested. Since parts are dollars, the best statistical sampling techniques must be used to get the most information from the least material.

One other point, well known to materials testers, is that a part may take a severe blow once or twice but fail after several impacts. In fact, if repeated impact is what your article must take, it is a good idea to test it in the same way. Usually it is best to obtain a plot of the number of blows required to cause failure against the height of drop (energy of the blow).

C. Is It Important That The Part Sustain Loads for Long Times?

Creep (deformation with time) is simple to measure. One merely simulates the expected load in magnitude and direction and measures bending or change in length with time. Those requirements may be time-consuming of course, and change after the initial deformation may be small. This property is usually very sensitive to temperature. Changes in creep rate of 100% with a 20°F. rise in temperature are not unusual.

Parts which deform very little under a given load may fail suddenly after long times of constant loading. While the tests take time, for some applications it may be important to test this property.

(Please turn to page 55)

SPEAKING OF EXTRUSION

Edited by **R. D. Sackett**
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Induction Heating for Plastics Extruders

Winchel J. Goodwin

Chief Electrical Engineer, Hale and Kullgren Co.

THE EXTRUDER has evolved from a rather simple assembly of drive, hopper, barrel, stock screw, and die, as used for extrusion of rubber products such as inner tubes, tire treads, preforms, etc., into a quite specialized machine for converting thermo-plastic resin powders and compounded formulations into pipe, automotive moldings, film, and many other products. With this evolution in use has come the need for accurately controlled application of heat to the extruder barrel. To accommodate different heat requirements along the length of an extruder barrel, the heating units are assembled for control purposes in groups, or zones, along the length of the barrel. The temperature in each zone is individually controlled. Before discussing the application of induction heating to plastics extruders, a review of present heating methods is in order.

Heating methods presently in use rely on heat transfer into the extruder barrel primarily by conduction. There are two basic heating systems in general use today. The first system involves the use of electric resistance heaters which are clamped more or less tightly to the outside surface of the barrel. They may be applied either as strip heaters, bent to conform to barrel contour, or as tubular heaters, either cast in aluminum or formed into machined or cast grooves. The latter arrangement is an attempt to achieve a more intimate contact between the heat source and the extruder barrel than is possible with strip heaters. When cooling is a requirement, as it usually is, the most common systems use air blowing over the surface of the barrel and heaters, either manually or automatically controlled. For efficient cooling, a chamber or tubular passage next to the barrel surface is desirable; However, such passages interfere with efficient conduction of heat from the heat source into the barrel. Thus, a compromise between the most efficient heating arrangement and the most efficient cooling arrangement must be made. The second basic system involves the use of heated liquid, or special oil. The temperature of the oil is regulated to maintain the desired zone temperature. This method will provide both heating and cooling, since heat flow may be either from barrel to oil or the reverse, depending on temperature relationship between extruder barrel and the oil. As a result of the conductive temperature drop due to skin resistance and thickness of metal, the liquid or vapor temperature must change considerably in order to maintain a fixed inner wall temperature during both heating and cooling conditions.

While the principles of induction heating are old, with patents extending back into the early 1900's, usage has been largely in the metal working industry. Here it is used for heat treating or surface hardening of steel and alloys and for heating of billets (steel, aluminum, brass, etc.) prior to extrusion, forging, etc. Before further developing the application of induction heating to extruders, a brief review of fundamentals is in order. Referring to Figure 1, you will note that a section of steel tubing around which a coil has been wound is shown. If an alternating voltage is applied to the coil leads, an alternating current (1) will flow

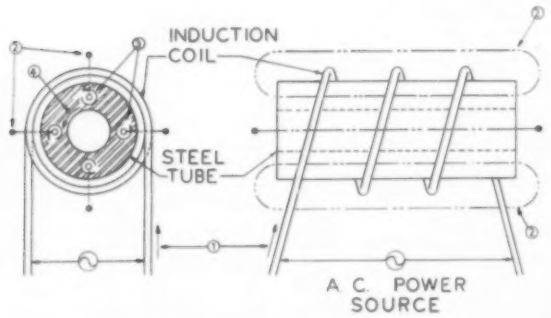

Figure 1. (Above) Induction heating system for an extruder barrel.

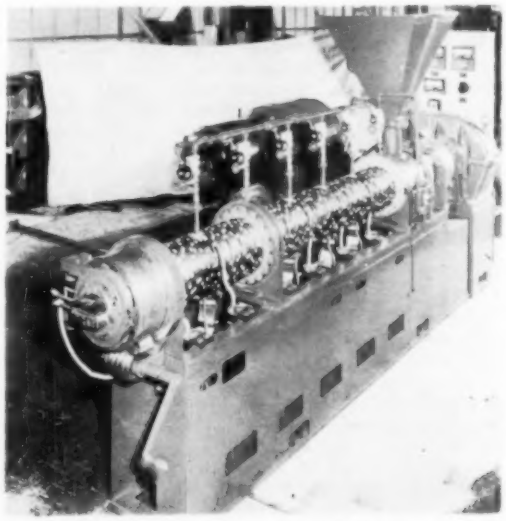

Figure 2. (Right) Production extruder barrel equipped with induction heating system.

(photo courtesy of Aetna-Standard)

through the coil. This current will cause an alternating magnetic flux (2) to flow through the tube with return through air outside the coil. This magnetic flux will cause a current (4) made up of minor currents (3) to flow through the tube. This current, by Ohm's law, will cause heating (watts=I^2R where I equals the current (4) and R equals resistance of the steel). Some additional heat will be produced by hysteresis and local eddy currents. A few of the fundamental characteristics of this heating method and their relation to extruder heating are:

1. Depth of heat generation is inverse to the frequency of applied voltage. For example, at 540 cycles per second (CPS) virtually all of the heating will take place in the first tenth of an inch (0. 10") of the steel cylinder shown in Figure 1; while, at power line frequency of 60 CPS, heating will take place through approximately one inch (1. 00") of the wall of the cylinder. Since the walls of most present extruder barrels are in the range of 1" to 1-1/2" in thickness, the advantages in use of 60 CPS are apparent since the desired heat will be generated throughout most of the wall thickness and conduction inefficiencies are minimized.

2. For any specific heating coil design, the amount of heating which can be obtained in a metal cylinder is considerably affected by the analysis of the metal from which the cylinder is fabricated. When this method is applied either to non-ferrous metals or to metals of high specific resistance, heating efficiency is likely to be poor.

3. Spacing between inside surface of coil and outside surface of the extruder barrel has, within limits, little effect on coil operating efficiency. Thus, insulation, along with a coolant chamber, can be placed between the coil and the extruder barrel, permitting efficient cooling.

As a result of experimental work, the following conclusions have been reached relative to the application of induction heating to plastics extruders:

a. Power consumption can be greatly reduced by this heating method. Reduction in heating costs by at least 75% are practical. For example, tests have been run on a 4-1/2" production type plastics extruder (L/D=20-1) equipped with induction heating coils. (Figure 2-Extruder Shown With Covers Removed). With the drive at rest, the entire barrel was brought from 80° F to 400°F in 20 minutes. During this time, the interval power demand was approximately 15 KW and the total energy consumption was 8 KWH.

b. Very accurate temperature control without need for elaborate controllers is possible. Due to absence of thermal lags, the simplest "off-on" type of control action will easily maintain metal temperature to within plus or minus 2°F, subject, of course, to controller measuring system accuracy.

c. Power factor (without capacitors) in range of 65% to 75% is below that of resistance heaters. However, due to the high heating efficiency, the maximum current demand will be less than that for resistance heated machines.

d. Efficient cooling can be combined with high heating efficiency to provide an excellent temperature control system.

e. Heating system reliability will be greater than resistance heating since induction coils can be of rugged construction, and they operate at relatively low temperature. Coil life should approach that of transformers such as used for plant power and light.

f. The first cost of an extruder equipped with induction heating may be higher than the same machine equipped with resistance heaters.

In addition to application to extruders, induction heating offers many possibilities in the heating of extruder dies, injection cylinders, and other plastics processing equipment. These systems have been developed for the Aetna Standard Engineering Company by Hale & Kullgren, Inc. and are now available for new and existing equipment. ★ ★

Molding Cycles . . .

(Continued from page 53)

D. **Must the Part Take Repeated Loading?**

As with impact testing, a part which may be able to take a given load or bend ten times may not be able to take it 100 times. When we wish to break a tough wire or rod, we bend it repeatedly. The fatigue properties of materials are provided you as curves of stress versus cycles to failure. Simulated service tests for fatigue life of parts are easy to set up. One pitfall must be avoided in all simulated service tests but especially here. Do not over-accelerate the stress or frequency of stressing. Some heat is developed with every cycle which, if not dissipated, changes the properties of material causing failures which will not necessarily occur in normal usage of the part.

III. **Permanence**

The material has been selected, perhaps with the help of your customer and your material supplier, to best withstand the environment in which it must work. Needed resistance to water, chemical, sunlight and to dimensional change has determined your choice. However, the part **you** mold **today** may not be as resistant to environment as the standard test piece molded by the material supplier or the part you molded last week.

Dimensional stability, mold shrinkage, resistance to crazing and weathering are all sensitive to molding variables. The measurements of initial changes of dimensions and further changes with time are straight-forward tests which are not difficult and may be made in many ways.

It should not be overlooked, however, that contraction with cooling from mold-to-room-temperature is not the only dimensional change which may occur. Effects due to changes in moisture content, molded-in stresses and their relaxation may be greater in some cases than simple mold shrinkage. Furthermore, while one dimension is decreasing another may be increasing, so it is wise to measure more than one and to make final checks at least twenty-four hours after molding.

Other surface effects under normal conditions, usually require long exposure times to evaluate. Fortunately acceleration of **these** tests usually, **though not always**, gives results which correlate with normal exposure. Solvent dip tests may expose surface stress by crazing which might not normally appear for long times. A few hours in an oven at a higher than normal use-temperature may show startling shrinkage due to improper molding. If not corrected this shrinkage might, at ordinary temperatures, cause trouble months later. If the material used is transparent, examination between a pair of crossed polaroids is an easy way to study effects of molding variables. A good part will show a minimum of colored bands in white light; an excellent part will appear uniform and color-free. One can, of course, be deceived by this test. All materials are not equally optically sensitive and stress in thin surface layers may not show any effect at all.

There are ways of testing molded articles for many other properties. However, appearance, strength and permanence are the properties which can vary most as a result of the molding process. If you have chosen your material wisely, and designed the part well, one or more of these tests may help you please and keep that valued customer. ★ ★

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Member Participation— SPE's Greatest Asset

IT HAS BEEN SAID that the strength of a membership organization stems from the voluntary participation of its members in its activities.

If this be true, then the SPE is strong indeed! The percentage of SPE's membership actively engaged in its work far exceeds that of most other societies. Furthermore, it would be difficult to find another group which could match SPE's dedicated members who willingly devote long hours—evenings and week-ends—to its welfare.

Such participation is truly SPE's most precious asset—its greatest strength! It is also the main reason why our society can operate so successfully with a staff considerably smaller than those of comparable organizations.

Encouraging and stimulating this cooperative effort and directing it into the most constructive channels is a vital function of our national officers and council. And assisting our officers to do so is a major responsibility of your Executive Secretary and his staff.

Unfortunately, however, the necessity to earn a living places a definite limit on the contributions that can be made by most members. It is therefore especially important that the time that they are able to devote to SPE be used efficiently.

Inefficient participation can occur when members spend time on projects that are not in harmony with, or do not advance, the objectives of our society while worthy projects are neglected; when several committees are duplicating or overlapping their efforts; or when members spend valuable time and effort doing things that the National Office is equipped to do for them—perhaps more efficiently.

Speaking of National Office functions, I believe that the purpose of a society staff is very simple—to provide the assistance and mechanisms that permit the members to participate effectively and efficiently. The staff exists mainly to free members of time-consuming details so that they can concentrate on those things that they can do best. Membership mailing, national publicity, printing, duplicating and publishing details are among the functions that our National Office is now equipped to take over. As our Society and our staff grow, this assistance of the National Office can be extended further.

Have You Mailed Your Membership Survey?

A cogent means of making our member participation more effective is the survey mailed to our membership late in December by our Membership Survey Committee. It will make available immediately by means of a punched card system in our National Office valuable information on each member. For example, knowledge of a member's area of technical interest may result in his appointment to a Professional Activity Group or Committee; his offer to serve on a committee or to write a paper could give him his first opportunity to participate in SPE activities.

So, if you haven't filled out and mailed your survey questionaire, please do so immediately. If you cannot find your form, let us know and we'll send you another. We need 100% return to get full value from this important project!

Thomas A. Bissell

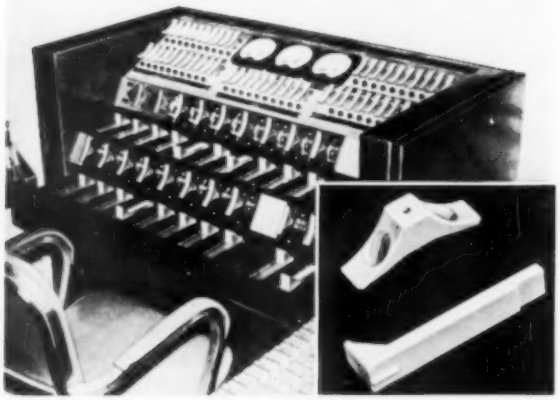
Executive Secretary

CYANAMID

PLASTICS IN ELECTRICAL DESIGN

An Ounce of Protection

KLIXON precision aircraft circuit breakers have to be light; yet even the smallest, weighing about 1¼ ounces, can safely interrupt a 120-volt ac, 400-cycle circuit delivering over 4000 amperes. To provide the high arc resistance and great physical strength required, Spencer Thermostat Div., Metals and Controls Corp., uses glass-filled CYMEL® melamine plastic housings. These non-corrosive housings are excellent insulators and stand up to impact, humidity, dust, temperature extremes and fire.



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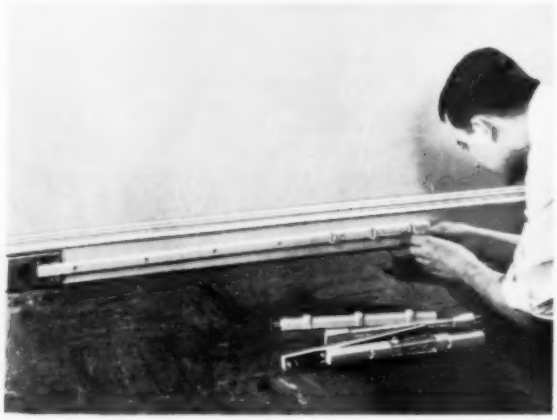
The Lumitron Lighting Control System permits one operator to play infinite variations in stage-lighting effects using handles and slide bars molded of BEETLE® urea plastic. BEETLE, an excellent dielectric, requires no insulation. Molded-in colors are permanent, permit quick circuit identification for console operator. Developed by Metropolitan Electric Manufacturing Company, the Lumitron has an excellent record of dependable performance.



New Low-Cost Electrical Outlet System

Made of ivory-colored BEETLE urea molding compound, new interlocking foot-long units provide low-cost, easily installed electrical outlet extensions. BEETLE combines good mechanical and dielectric properties for safe, dependable service, meeting ASTM Specifications D705-49, Grade I. Made by Cable Electric Products, Inc., this new Snapit Inter-Link System is fully approved by Underwriters Laboratories, Inc.

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NEWS of the industry

Testing Machines

Plas-Tech Equipment Corporation, a new company serving the plastics and allied industries, has taken up quarters at 751 Main Street, Waltham, Mass. The company manufactures a new high-speed testing machine for measuring tensile, flexural and stress-relaxation properties of materials at exceptionally high rates of loading. In addition, the firm offers a complete consulting service to the plastics industry with special emphasis on research and development and materials testing and evaluation. For testing under controlled conditions a special air-conditioned laboratory has been installed to conform with ASTM specifications on plastics.

Melvin Silberberg and Ross H. Supnik constitute the active management of the corporation. The Board of Directors includes, in addition to the above men, S. Ralph Margulies, President of Research Council, Inc., and Frederick J. McGarry, Assistant Professor of Materials, M.I.T.

Technical Papers Sought

An invitation for technical papers has been extended by the National Program Committee of the American Society of Tool Engineers. Accepted papers will be presented at the ASTE Semi-Annual Meeting and Western Tool Show to be held in September, 1958 in Los Angeles.

ASTE membership is **not** required for the submission of a paper. Each proposal should include an outline of the paper, the author's name, his title and affiliation.

Authors must also agree to abide by the published rules for presentation of papers before a national meeting of the ASTE.

Outlines should be sent to: L. S. Fletcher, Program Director, American Society of Tool Engineers, 10700 Puritan Avenue, Detroit 38, Michigan.

Resistance Measurement

The new Trump Type 9 Resistance Sample Holder provides a convenient means of measuring both surface and volume resistances of molded plastics. Holder conforms to the requirements of ASTM method D257-54T. Designed as an accessory tc the Trump type 8 Electrometer-Megohmmeter recently announced, the Type 9 Resistance Sample Holder may however be used with any resistance measuring equipment. Volume and surface resistivities to at least 10^{17} ohm-centimeters or ohms per square may be measured. Write to Walter N. Trump, 516 S. Vermont Avenue, Columbus, Kansas.

Fiber-glass Laminates

A new patented process and tool for production of fiber-glass laminates which drastically reduces both labor and material costs has been announced by Rand Development Corporation, Cleveland, Ohio.

The new tool is a three-way gun which sprays activated resin and chopped fiber-glass strands simultaneously and is called the Rand Fiber-Resin Depositor. The tool will deposit up to 15 pounds of high strength laminate per minute, and is designed for operation by one man. It can reduce the costs of laminating large parts such as a 14 ft. boat as much as 40%.

Phenolic Resins

Akron Chemical Co., 255 Fountain St., Akron, Ohio, is now handling the sales and service of Hooker Electrochemical Co.'s Durez Plastics Division's phenolic resins for the rubber industry in Ohio, Indiana, Michigan, Western Pennsylvania and Western New York.

Synthane Corp.

Synthane Corporation, Oaks, Pa., manufacturer of industrial laminated plastics, has relocated its Cleveland sales office at 3597 Lee Road, Cleveland 20. This office was formerly in the Western Reserve Building, 1468 W. 9th St., Cleveland. Foster A. Hall is Synthane's District Sales Representative in Cleveland.

New Catalysts

National Lead Company and Celanese Corporation of America today announced their collaboration in research on improved polymers for plastics and fibers using newly-developed polymerization catalysts. These catalysts, products of National Lead Company's research laboratories, are reported by the two companies to constitute an important break-through toward successful production of unique polymers, including radically new types of polypropylene and polystyrene.

Offices Changed

The Pacific Division offices of Mycalex Corporation of America and associated companies are now located at 2810-1/2 Glendale Boulevard, Los Angeles 39, California. Richard H. Hall is Sales Manager of the Pacific Division, assisted by Robert L. Burr as telemetry specialist, and Miss Jeanne Lamoreaux in charge of sales service and order service.

Men In The News

Weaver Awards

Ferro Corporation, Cleveland, Ohio, has honored two of its West Coast representatives in the plastics field. John N. Rodgers, Sales Engineer for Ferro's Los Angeles Plastic Color Department, and Ralph C. Riggs, Manager of Ferro's Fiber Glass plant in Huntington Beach both were recipients of this year's Robert A. Weaver Awards for their "outstanding performance beyond the call of duty."

Byron D. Babcock

Byron D. Babcock, a chemical engineer at Du Pont's Washington Works, Parkersburg, W. Va., has been promoted to research supervisor in the Research Division of the Polychemicals Department at the Experimental Station, Wilmington.

Russell C. Weigel

Russell C. Weigel, director of plastics sales in Du Pont's Polychemicals Department, has been appointed assistant general manager of the department, it was announced today.

His appointment, together with that of Walter H. Salzenberg as general manager of the department, was effective January 1.

Harold H. Goldstein

Harold H. Goldstein has been appointed to the newly created post of Product Sales Manager for the Structoglas Division of International Molded Plastics, Inc. In his new position Mr. Goldstein will be responsible for direct supervision of sales representatives for Structoglas reinforced plastic panes, panels, awning and patio materials.

Charles E. Trescott

Capt. Charles E. Trescott, U. S. N. (ret.), has been named manufacturing manager of Zenith Plastics Co. of Gardena, Calif., a subsidiary of Minnesota Mining and Manufacturing Co. Trescott will be responsible for all manufacturing departments of the southern California plastics firm, including tooling and production, according to Brucker.

Jesse H. Day

Dr. Jesse H. Day, Associate professor of chemistry at Ohio University, has been named a Fellow of the New York Academy of Science.

The title was conferred upon him and a "limited number" of other scientists for "outstanding work toward the advancement of science," executive director of the academy, E. T. Miner, said in conferring the title.

Dr. Day is recognized as a national authority on fulvenes, a class of compounds, and has worked as a research chemist in the field of plastics and synthetic rubber. He is editor of "The Society of Plastics Engineers Journal."

Industrial Literature

Outdoor Exposure Resistance

Resistance Of Plastics To Outdoor Exposure. R. B. Barrett, Picatinny Arsenal, U.S. Army Ordnance Corps. Feb. 1955. 268 pages. (Order PB 131-331 from OTS, U. S. Department of Commerce, Washington 25, D. C., $6.) This handbook was prepared as a guide to Ordnance Corps engineers in the selection of plastics for use in outdoor exposure. Weather resistance data for 72 commercially available plastic materials was accumulated, together with information on the effects of additives, fillers, and other modifiers. The materials were grouped as thermoplastics, thermosets, cellulosics, laminates, and elastomers. A detailed formulation of each material, the condition of its fabrication, a statement of its special properties, and applicable Government specifications are presented. The plastics are rated according to good long-term resistance, good short-term resistance, poor resistance, and resistance dependent on modifiers.

Pipe Specification

It is the intent of the Bureau of Ships to change the cost allocation of qualification tests for Specification MIL-P-19119, Pipe, Plastic, Rigid Unplasticized High Impact Polyvinylchloride. The terminal date for receipt of requests for tests at Government expense is 28 February 1958. Qualification tests requested after that date will be at the manufacturer's expense.

Copies of the specification may be obtained from the Commanding Officer, Naval Supply Depot, Scotia 2, New York.

Ink Data Sheets

Claremont Pigment Dispersion Corp., 39 Powerhouse Rd., Roslyn Heights, N. Y. offers a set of data sheets on inks for printing on vinyls.

Cleaning Machines

The Wheelabrator Corporation, 1258 S. Byrkit St., Mishawaka, Indiana, announces a new 32 page illustrated catalog No. 951-D, covering the company's entire line of airless blast cleaning machines as well as wet blast, air blast and dust control equipment. Also included are cast steel shot and grit abrasives, sandcutters and core rod straighteners.

Thermal Properties

Investigation Of Thermal Properties Of Plastic Laminates, Cores, and Sandwich Panels. Part 2. F.R. O'Brien and S. Oglesby, Jr. Southern Research Institute for Wright Air Development Center, U. S. Air Force. Nov. 1955. 79 pages. (Order PB 121191 from OTS, U. S. Department of Commerce, Washington 25, D. C. $2.) Thermal properties were measured for a selected group of plastic laminates, cores, and sandwich panels. Properties measured included specific heat from 100 to 600 F, thermal conductivity, and coefficient of linear thermal expansion from -100 to 600 F. The test materials were four laminates with 181 glass fabric reinforcement but with four different resins: three ½-inch thick, foamed-in-place alkyd-isocyanate plastic cores; one ½-inch thick, foamed-in-place heat-resistant plastic core; one foam sandwich panel; and one honeycomb panel. Thermal properties of laminates were compared with those of laminates tested in the first part of the research (the report of which has not been released for publication). Foam cores, except the heat-resistant core, decomposed at relatively low temperatures.

Plaskon Compounds

A full-color folder which points the way to new products, new uses and new markets through the use of Plaskon molding compounds has been prepared for designers, molders and manufacturers.

Products made of Plaskon Urea, Melamine and Alkyd molding compounds and Plaskon Nylon molding and extrusion compounds are listed and illustrated and outstanding properties which make each molding compound ideal for these specific applications are briefly described. Designated P-95, the folder is offered by Barnett Division, Allied Chemical & Dye Corp., 40 Rector St., New York 6.

Chemical Intermediates

The Carwin Company has published a new 28-page product catalog, describing the company's complete product line including chemical intermediates for the dyestuff, pigment and pharmaceutical industries, as well as isocyanates for foam, adhesive, resin, elastomer and other end uses. Write: The Carwin Company, North Haven, Connecticut.

Circuit Etching

The new Becco process for etching printed circuits with a solution of ammonium persulfate instead of ferric chloride is described in a new Becco Bulletin, No. 90, just published by Becco Chemical Division, Food Machinery and Chemical Corporation, Buffalo, N. Y.

Advantages of the persulfate bath over ferric chloride include: the etchant is relatively non-corrosive; sludge formation is avoided; only water-soluble reaction products are formed; solder-plated circuits can be etched; copper can be recovered from the spent etching solution; waste solution can be disposed of easily.

Copies of Bulletin 90 may be obtained free on request from Becco Chemical Division, Food Machinery and Chemical Corporation, Station B, Buffalo 7, New York.

Polyethylene Adhesion

A special laboratory report on the adhesion of polyethylene to metals highlights the current issue of the Plastics Weldor and Fabricator, the external house organ of the American Agile Corporation, Maple Heights (Cleveland), Ohio.

Also included in this issue are two case studies: the first details the application of polyethylene tanks to reduce maintenance time and costs during anodizing and plating operations; while the second illustrates and describes the use of a polyethylene fume exhaust system to slash corrosion costs in an industrial laboratory.

Other editorial items include information on the use of polyethylene in the production of an automatic washer tub; new literature covering the subject of fluidized plastic coatings; and details on two new products just developed by the company. Copies may be obtained without cost from the American Agile Corporation, P.O. Box 168, Bedford, Ohio.

Petrochemicals

Amoco Chemicals Corporation has just issued a 24-page general product brochure which describes the company's line of petrochemicals for the paint, plastics, rubber, chemical, petroleum, detergent, agricultural chemicals and other industries. Tables of typical properties are also included. Copies available on request to Amoco, 910 S. Michigan Ave, Chicago 80, Illinois.

PVC Stabilization

A 23-page technical bulletin has just been issued by Argus Chemical Corporation on the stabilization of polyvinyl chloride. The bulletin deals with barium-cadmium stabilizer systems and the applicability of various Argus Mark Stabilizers for specific functions. Contains detailed technical data on each item.

AROUND THE WORLD

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UNITED STATES
ELECTRICAL MANUFACTURING
December, 1957

Abstracter: W. A. Kelly

Research Progress in Dielectrics — 1957 — *A. E. Javitz, Special Features Editor*

Eleventh consecutive annual staff on the Conference on Electrical Insulation (National Academy of Sciences National Research Council). Papers and round-table discussions are summarized and interpreted, test results are given. Synthesis of materials for supersonic missile and aircraft requirements; behavior of silicones under radiation; degradation of Mylar film; insulation life of flexible insulation; mechanisms of electrical breakdown; and "treeing" in polyethylene cable are among subjects discussed.

★

MATERIALS IN DESIGN ENGINEERING
November, 1957

Abstracter: Leonard Buchoff

Designing for Compression and Transfer Moldings—*James E. Johnston*

The basic compression and transfer molding operations are described concisely and clearly. Properties and molding characteristics of phenolics, urea, melamine and alkyd resins are given. The main part of the article concerns factors to be considered in designing molded parts.

This article is an excellent guide for picking the best material and physical details for a successful injection or compression molded piece.

Materials for Gears — *Norman E. Woldman*

The last part of this article describes the selection of plastic gears for their silence of operation, resiliency, vibration damping properties and low cost in large quantities. Molded and laminate phenolics are used for their good strength and dimensional stability over wide ranges of conditions. Nylon is used because its resiliency and wear properties give excellent service life. Nylon's heat and moisture sensitivity may cause malfunction in improperly designed gears. Polystyrene and vulcanized fiber are also mentioned.

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AUSTRALIA
PLASTICS AND RUBBER JOURNAL
October, 1957

Abstracter: Albert Lightbody

How to Predict Extruder Performance — *B. H. Maddock*

The theoretical flow and screw design equations apply very well in extrusion of polyethylene with metering type screws when the terms, "effective resin viscosity" and "effective screw length", are properly interpreted. The effective viscosity of polyethylene is a function of the rate of shear in the channel or orifice through which the resin is flowing and data on this property are presented. Since the rate of shear in the screw channel may be widely different from that in the die the two areas must be treated separately. Graphs showing the relationships between extrusion rates and operating characteristics of polyethylene give a great deal of information on practical prediction of extruder performance.

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FRANCE
INDUSTRIE DES PLASTIQUES MODERNES
November, 1957

Abstracter: Hans Mayer

The Making of Airplane Models from Reinforced Plastics — *G. Dixmier and L. Lansac*

Aerodynamic experiments require models of exact dimensions, strength and high surface finish. Plastic materials suggest themselves on account of the savings in machining. Since the small number of parts required eliminates the possibility of using materials which polymerize under high pressure, polyester had to be chosen. The need of finding the proper formulation of the resin itself as well as the proper choice of a suitable glass reinforcement are explained and the process of building suitable molds as well as the molding process itself are described.

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PENSEZ PLASTIQUES
October, 1957

Abstracter: Kenneth Downing

The Silicones — *F. J.*

A short history of the silicones is presented. The outline of the chemistry of the silicones is next presented.

Various industrial fabrication methods are outlined.

1) Grignard reaction.
2) Rochow direct method.
3) Addition method.

Articles note that Dow-Corning uses the Grignard method and General Electric uses the direct method which is more simple than the Grignard procedure.

The industrial products, fluids, resins and elastomers of silicones are next described and the chemical formulas given. A complete table of the properties of the silicones follows these descriptions.

The article includes a brief discussion of the manner of fabrication methods, the applications of each type fluids, the controls and the commercial markets for the materials.

Le Kaetolon (new French Cellulose)

Announcement is made of a new cellulose acetate compound under the name of Kaetolon. (A.P.K.-U-).

Its outstanding characteristics are

1) Resistance to impact.
2) Better rigidity.
3) Very easily molded.

A chart of the properties of this material is included in the article.

November, 1957

Special Edition

This issue is devoted to a pictoral study of the plastics produced in France for children. It includes dolls, boats, various playthings, childrens furniture, and musical instruments.

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GERMANY

KUNSTSTOFFE

November, 1957

Abstracter: Anne Schwend

Open-Cell Foams for Acoustical Purposes in the Building Industry — *H. W. Paffrath*

A review of the mechanism of sound absorption through deadening sound energy, caused by oscillating air particles, within open foam cells and through internal dampening as well as the resonator effect of partly film—or varnish-covered foams and their application in modern building.

Sound Deadening of Car Bodies Through Plastic Foams—*E. A. Hampe*

An introduction into the appearance and frequency of booming sounds in automobile and rail cars is followed by a detailed description of remedies in the form of layers of foamed plastics with a covering flat layer of rubber, bonded to car bodies by suitable adhesives. Relatively thin layers of "Moltopren" foams with a rubber cover force a loss factor of a magnitude of .1 within the range of low frequencies upon the chassis thus covered. Recent developments of rigid foams which may possibly gain in importance as sandwich structures on light metal sheets in the aircraft industry have not yet been considered in this article.

Calculation and Design of Slit Nozzles — *H. R. Jacobi*

A compilation based on a similar article in Modern Plastics of August 1956, pages 127/36.

Measuring the DC Resistance of Technical and Pure Polymers — *J. H. Kallweit*

DC measurements under high vacuum and under elimination of all factors that might possibly influence the result were made with varying field intensity, temperature, time and polarity. The author succeeded in confirming previous results and finding new values which clearly show an influence of the structure of polymers. The following hypothesis was established for the mechanism of conductivity of polymers: The initial orientation of polar molecules, which causes displacement current, effects an increase in resistance immediately after exposure to current. The superposed stream of ions, facilitated through an exchange of places, soon becomes the main carrier of electricity. It is highly dependent on temperature. The ions are only partly being discharged immediately so that a thermal equilibrium of current forms since discharge at the electrodes is also dependent on temperature. The remainder of current may be caused by newly forming ions (thermal dissociation, γ-radiation) and by electron conduit. At higher temperatures a purely electrolytic conduit superposes itself.

Tolerances for Compression and Injection Molded Parts

Presentation of revised standard DIN 7710 for tolerances allowable for compression and injection molded parts. Discussion and revision of this standard is necessitated by increased technical exigencies, new molding compounds and progressing typization of compounds.

Avoiding Dust Explosions in the Plastics Industry

Excerpt from the specifications compiled by the National Board of Fire Underwriters and the SPI Committee "Prevention of Fire" on possible measures to avoid explosions in dust-laden workshops for plastics processing.

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KUNSTSTOFF-RUNDSCHAU

October, 1957

Abstracter: Leo Fischer

Synthetic Film in Building—*K. Evelt*

The most important application in building of film materials is polyethylene. The useful quality in this application is the water and vapor resistance of polyethylene film. Insulation to cold and heat is accomplished not so much by the insulating qualities of the film as by the air pockets created by two thicknesses of film. Polyethylene film is widely used in covering fresh laid concrete and 1mm. film is generally used. Covering of wooden forms for concrete casting, where the film is used as separater, is also a widespread application. However, since the surface obtained is extremely smooth, film should not be used when plastering or stucco is necessary. Film used under the mortar in flooring is another application. A tent-like protection over new buildings to protect against weather and rain has been widely used as well as covering building materials and machinery. Another promising use for this film is in roofing.

Synthetics in Chemical Apparatus — *Dr. W. Pungs*

PVC, polyethylene, acrylics, and polystyrene are the most widely used thermoplastics for chemical apparatus. Phenols and polyesters are the most important among the thermosets. PVC is used where acid and alkali resistance is required as well as impermeability to gas and moisture. Flame resistance can also be obtained with PVC. Rigid PVC is used in sheets, tubes, rods, and blocks for fabrication. Since PVC can be bent, drawn and blown and welded it lends itself to low cost fabrication.

Low pressure polyethylene, having a higher softening point than PVC, is entering new fields in chemical apparatus. Since adhesion and welding is not efficient in polyethylene, mechanical bonds are used. For high temperatures, polyfluorethylene and other fluorine resins are used. The largest use of synthetics in chemical plants is ducts, stacks and tubes for gases and exhausts. Large reaction kettles have been made. Polyethylene when used as a coating material can be hot sprayed or a sintering technique may be used.

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DER PLASTVERARBEITER

October, 1957

Abstracter: Leo Fischer

Unusual Qualities of Silicon Installation — *Roger Mercier*

The high resistance to moisture makes silicons especially valuable in electric technology. Resistance to the highest frequencies, to high temperatures, to chemical reaction, and to acids and ozone are the important attributes of silicons. The viscosity of silicons is one hundred times as stable under heat variation as any other oil or grease. An electric cable to carry 5KV consists of 19 strands of .07mm of copper wire with a total diameter of 2.6mm. A silicon coating is applied making a total diameter wire of 5mmT to carry 5KV. To obtain a 25KV cable .35mm copper wire is used.

Silicon greases retain their thixitropy under all ordinary conditions. Various techniques of applying silicon are given especially for condensers and other electric apparatus. Silicons are also used as lacquers to coat equipment, pipes, armatures, etc.

Old and New Synthetics in Electric Technology — *Dr. H. Kalpers*

Phenolic resins were the earliest synthetics used in the electric industry. Their dielectric constant, however, is greatly reduced when wet. Phenolics generally are not suitable for high frequencies. Melamines are used for housings chiefly, having very good insulating qualities. Polyesters have not made extensive inroads in the electrical field. Epoxies are being more widely accepted. PVC has the largest place in electric technology. It is the most widely used wire coating due to its abrasion and temperature resistance. Polystyrene and polyethylene are used where high resistance to high frequencies is required. Polyethylene is now being adapted for under water cables. Polyamids are used mostly in machine and instrument work. The cellulosics are use-

ful where injection molded parts that require electric resistance are required.

Technical Directives for Polyamid Molding — *Werner Oleff*

In an article describing special techniques required in molding polyamids the author stresses particularly that "post pressure" is very essential. After the molded polyamid has cooled to rigidity in the mold, further pressure seems to be useless. But this is entirely wrong, claims the author. Maximum density is only obtained by "post pressure." Additional pressure after the molding of the piece affects not only the piece in question, but densifies the polyamid in the cylinder and thus improves it for subsequent moldings.

The Technique of Wire Coating — *Jean Peynichou*

This third article on wire coating discusses the problems of using PVC with fillers. Stabilizers are essential and it is advised that often a combination of stabilizers as well as a combination of plasticizers and inorganic additives be used. A stabilizer must accept HCL released by hot PVC, must absorb ultra violet rays, and must also prevent oxidation by ultra violet rays. It should have a refractive index similar to PVC in transparent products. The general classes of stabilizers are zinc, lead, sodium, barium, cadmium, calcium, strontium, cobalt, epoxides, and tin.

About the same characteristics as described above are required in plasticizers, except that migration and boiling point have to be considered. The author cautions about the use of coloring pigments and advises tests after each change of plasticizers or stabilizers.

House Recipes for Dry Coloring of Thermoplastics — *J. Coudenhove-Kalergi*

The author recommends the use of small granules in dry colorings of thermoplastics. They should be agitated with .05% to 1% wetting agent before adding color in order to build up static electric charges on the surface of the granules. The pigments then will adhere much better and more uniformly to the granules. Putting the mix through an extruder and strainer does improve the color dispersion but the author feels that in most cases this is not necessary. He warns that fluorescent and metallic pigments and some soluble dyes may be poisonous and should be carefully checked.

Problems in Molding Plexiglass — *E. Friederich*

The author advises using high pressure in molding acrylics, obtained by means of a high pressure cylinder and a torpedo. The important thing is to keep plastification uniform even under rapid injection. He recommends the Polyliner Cylinder, made in America. In molding lenses it is suggested that molds be made with only a few cavities. The movement of the resin must take place at temperatures over 150°C as the material starts to freeze below that and flow marks will be visible. That is why high injection speed and high temperatures are necessary.

Pinpoint gating is recommended but has to be carefully designed. High pressure will not substitute for smooth flow. The author recommends an equalization chamber in the mold, that is, a wide, short conical gate channeled into the pinpoint gate.

Forming Techniques for Acrylic Sheets — *Heinz Greiner*

If the ratio of depth to diameter is 1 to 4 or greater, a holding ring has to be used and the loss in material is usually 20%. If the ratio is less, no holding ring is required and the loss is only 10%. Acrylic sheets can also be formed by blowing, as it is possible with this technique to stretch the sheet 400% without distorting surfaces. Formulations for determining the resultant thickness of cross sections after drawing acrylic sheet are given. The use of tanks to obtain vacuum as well as pressure so as to keep the pressure uniform is recommended. A combination of pressure and vacuum with a plunger mold gives the most uniform result in the forming of acrylic sheets.

Dynat, A New Type of Closure

A zipper is described that hermetically seals against air, gas and water. The zipper will withstand pressures up to four atmospheres. The principle is that each half of a silver alloy zipper is secured to a plastic band which is turned under and upon pulling the zipper the two flexible plastic bands are pulled tightly together and held that way.

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ITALY

POLIPLASTI

September-October, 1957

Abstracter: Alfred L. Alk

Mass Coloring Cellulose Acetate, Polystyrene and Polyethylene Molding Materials

Pigments and dyes used for coloring plastics materials must have attractive colors, must be easily dispersible as dry powders, must be stable to light and heat and must not migrate. The article discusses procedures for determining whether colorants meet the requirements, and the results obtained for the subject materials.

Plastic Materials in the Aircraft Industry — *A. Foulon*

The author calls attention to the application of common and novel materials in current aircraft construction.

Olympia—The British Plastics Exhibition

Photographs and brief descriptions of new products and equipment exhibited at the 4th annual show. Also abstracts of papers presented in the technical sessions.

July, August

The Gas and Liquid Permeability of Plastic Films — *Franco Sabbioni*

The author describes an apparatus for precise permeability determinations. Refinements which have been made in the usual methods and which have produced more valid and reproducible measurements are discussed in some detail. Results attained with several polyethylenes are presented and compared with published literature references. (Illustrated)

Hupfield 2¼ ounce injection press

Complete description of a newly introduced press manufactured by Hupfield Brothers, Ltd.

Fabrication of thermoplastic sheets with a flat die

Description of a complete sheet set-up offered by Kleinewerfers. It features a 3.6", 24 L/d extruder with 5 controlled zones; a 52" die with seven controlled zones with internal adjustments to allow for a range of materials; and a takeaway train with individually controlled stack rollers. The unit is said to be capable of 200-250#/hr at .020-.200" stock.

The Automatic Preforming of Glass Fibers

Two machines offered by Friedrich Busch, one consisting of a chamber to which is introduced up to four strands of roving at once which are chopped and deposited by air flow on a rotating mandrel located in the center of the chamber; the other a self contained unit for making mat which is capable of 180-240 lbs per hour. It uses up to 6 strands, applies binder, and bakes before reaching either rolls or an automatic cutoff.

The Molding Characteristics of Linear Polyethylene — *F. J. Rielly, V. Hill, D. A. Jones*

Reprint of an article which appeared in the April 1957 issue of SPE Journal.

The Performance of Colors in Plastics — *R. Deverell-Smith*

Increasing use of organic colors in plastics has focussed interests on areas of difficulty with pigment bleed-

(Please turn to page 70)

SECTION NEWS

Edited by
David Mersey
190 Camden Road
Hamden, Connecticut

Kansas City

Properties Listed Of Methyl Styrene

K. A. Kaufmann

The November meeting of the Kansas City Section took place the evening of November 20, 1957, at Wolferman's Restaurant on the Country Club Plaza.

Mr. Art Nugent of the American Cyanamid Company was the main speaker of the evening. The very interesting program was devoted to Cymoac, the new methyl styrene resin offered by American Cyanamid. The injection molding characteristics and physical properties of methyl styrene resins were described, and graphs were used to clarify the more important points of the presentation.

The comparisons drawn between methyl styrene and styrene were of special interest to the members because of their familiarity with the properties of styrene. According to Mr. Nugent, methyl styrene has a higher heat distortion temperature and better mar resistance, toughness and retention of clarity.

The program was very well received by a group of about forty members.

October

The October meeting of the Kansas City Section took place on the evening of October 10, 1957 at Wolferman's Restaurant at the Plaza. We were very fortunate to have nearly all the members of the National Council of SPE present for the meeting. All the members were introduced to the Chapter, and several of the National Councilmen responded with brief, interesting remarks. Mr. Peter Simmons, chairman of the National Council outlined the future plans for S.P.E.

The meeting was very stimulating to the Kansas City Chapter, and all of us now have a better idea of the scope of S.P.E.

R. I. and S. E. Mass.

Christmas Party

Glenn A. Tanner

The December meeting of the RISEM Section is traditionally a Christmas party, during which the only business discussed is the announcement of the officers elected for the coming year. The rest of the evening is relegated to fellowship and the enjoyment of the festive spirit.

The Christmas party this year was held at the B & B nightclub in Johnston, R. I., on Thursday, December 19th. The evening began with a cocktail hour followed by a seven course steak dinner and a floor show.

Mr. Sydney Lohman of Lester-Phoenix, Inc. announced the slate of officers who had been elected to govern the organization through 1958. He turned the gavel over to Mr. Charles Chrones of Hassenfeld Brothers, Inc. The other new officers are, Vice President—Howard Amster of Reliance Molded Products, Inc., Treasurer—A. J. Krajewski of A. J. Krajewski, Inc., Secretary—Glenn A. Tanner of Ralph B. Symons Associates, Inc. The balance of the Board of Directors consists of Mr. William Monahan, Mr. Morris Chafetz, Mr. Samuel Greene, Mr. Howard Bangs, Mr. Althen Lindstrom. Our National Director, Mr. Robert Johnson of Monsanto has two years remaining in his elected term.

Southern

Dinner Dance

E. O. Redwine and R. E. Welch

A dinner dance for members, guests and their wives, was held at the Cherokee Country Club, Atlanta, Georgia, on December 16, 1957. Approximately 60 people attended. Entertainment was furnished by a dance team from a local dance studio.

Officers elected for the forthcoming year were announced. These are: President, William B. Erb, Celanese Corporation of America; Vice President, Jones P. Sipe, Koppers Company, Inc.; Secretary, E. O. Redwine, B. F. Goodrich Chemical Company; Treasurer, Martin G. Hofmann, Lamex, Inc.

The next regular meeting will be held at the usual meeting place — Architects and Engineers Institute Building, Atlanta, on January 20, 1958. This meeting will feature an after dinner tour of the Industrial Design School of Georgia Tech.

Eastern New England

Ladies Night

Charles P. Pechulis

The annual "Ladies Night" Christmas Party was held on December 10th at the fabulous Colonial Inn in Lynnfield, Mass. with the usual large attendance. Christmas corsages were given to all the ladies.

The evening started with a social hour, followed by a delicious dinner. After dinner, numerous door prizes were given out, which were donated by the firms represented by its members. Dancing and a social brought a most enjoyable evening to a close.

New and Outgoing RISEM Presidents

Sydney Lohman, Lester-Phoenix, Inc., congratulates Charles Chrones, Hassenfeld Bros., who was elected to succeed Mr. Lohman as president of the Rhode Island and Southern Massachusetts section.

Southern California Christmas Dance

The ladies with the pleased smiles are those lucky spouses of the Southern California Section who attended their annual Christmas Dance. The door prizes were an extra bonus to our members and their best girls. Baskets, bowls, key holders, and water pitchers were included in these gifts. In addition, special drawing prizes were donated through associated companies in the area.

As usual, all enjoyed a full evening of fine food, excellent entertainment, and extraordinary good-fellowship. The program included an introduction of next year's board members—Messrs. Costanza, Delmonte, Dixon, Fuller, Harris, Schaub, Stahmann, Steinman, and Zimmerman. Through the efforts of the efficient committee, the evening's entertainment ended with after-dinner dancing to a three man combo.

Detroit

Christmas Party A Big Success

Russ Stanhope

Well, they went and did it again! Every year that a Christmas Party has been given by the Detroit Section of the S.P.E., we were certain that it could not be surpassed. But, as we said—they went and did it again. Bigger and Better than Ever!

Over 300 ostentatious plastic engineers and their resplendent wives squeezed into their dancing shoes and wended their way to the Grand Ballroom of the Sheraton Cadillac Hotel to partake of the festive soiree.

Friday, December 13th may have been a dire day for many less fortunate people, but to those in attendance it was a gala occasion.

Under the Chairmanship of Mike Herzina, the party moved smoothly with a delicious dinner, followed by short speeches, a sparkling floor show, the distribution of well chosen prizes for everyone, and dancing to the rhythmic melodies of Russ Weaver.

It was quite a revelation to your reporter to see so many staid and pompous executives who, during their normal working day are mostly too tired to check a material color chart, grinning sheepishly as they snapped their fingers and cut a wide swath as they brazenly maneuvered "The Little Woman" around the dance floor.

Judging from the dainty dance steps that many of the men were taking, we are not certain whether their shoes were two sizes too small or whether they were the victims of "Bakelite Bunyans," but we are certain that many of them would have felt more comfortable dancing the Minuet in their bedroom slippers.

After the dying strains of the "Good Night Waltz" had wafted through the ballroom, you were certain that all was well in the plastics realm because everyone was planning on coming to the party next year.

Chicago

New Officers

Joseph J. Schmidt

The Chicago Section Board of Directors met on December 17th to learn section election results and to elect officers for 1958. Elected as Directors for terms expiring December 31, 1960 were: Frank Moore, Rohm & Haas Company; Robert Reynolds, Artag Plastics, Inc. and Earl Wilson, Perfex Plastics, Inc.

Gib Baccash, Lind Plastics Products, was elected Chicago Section President for 1958. Ray Daniels, Amos Molded Products Co., will serve as Vice-President, and Earl Wilson as Secretary-Treasurer.

Ken Gossett, Gossett & Hill Company, was reelected National Director for a term to expire in January, 1961.

W. New England RETEC

The section has announced its plans to sponsor a regional technical conference on "Plastics in Packaging."

Approved early in January by the National Council, the RETEC has been scheduled for October 1, 1958.

Blakely R. McNeill (Fuller Brush Company) has been appointed general chairman.

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New York — Newark

Finishing, Controls And Thermoforming

Charles C. Orr

Members of SPE's New York section and its reinforced plastics subgroup, together with representatives of the Newark section, converged on New York City's Governor Clinton Hotel November 20, to attend the semi-annual joint dinner and meeting. Five speakers addressed the group on the various aspects of finishing, and thermoforming, of plastics products, as well as the need for quality and production control in the manufacture of reinforced plastics. Among the guests attending the conclave were Peter Simmons, SPE's national president, and Thomas Bissel, newly appointed national secretary.

Arthur N. Skeels, Art Roll Leaf Stamping Co., talking on "Hot Stamping and Silk Screening Operations," pointed out that thermoplastic and thermosetting materials present individual problems to the decorator. Of the four methods of decorating, the hot stamping process lends itself most readily to both types of molded products with the exception of ureas and melamines. For best results, close attention should be paid to heat, pressure, dwell-time, and selection of the proper leaf. The silk screening process is adaptable to rapid production and results in an end-product having good quality and wear resistance properties. While injection molded products cannot be easily silk screened, blow molded articles can. Most of the difficulties arise from faulty mold design, resulting in a lack of dimensional tolerances and non-uniformity of gate especially in multiple cavity molds. The mold designer and decorator should cooperate in the initial phases of product design to insure economic handling during manufacture.

In the evaluation of plastics metalizing, Harold Mesburg, Vacuum Metalizing Co., outlined the history of the process which was developed from early methods of vacuum deposition of silver nitrate on lenses to produce mirrors. He stressed the need for closer coordination between molders and metalizers in order to deliver a well finished product at a minimum cost. Too few fabricators see the object in its final form, and are unaware that metalizing will not hide imperfections. Often minor dimensional changes in the molded item can reduce the cost of metalizing by 30-40%. A finer product can be made by breaking up surfaces with an engine turned effect incorporated into the mold design. Sculptured and flowing surfaces also help hide imperfections, but in general it is best to use a good quality molding material and to spend more time and effort during mold lay-out to reduce the cost of metalizing.

John Ostock, Standard Toch Chemical Co., in discussing the painting of plastics items stated that wear and resistance properties must be built into the coating. One of the major problems in paint and lacquer formulation involves the selection of a proper solvent. It must be weak enough not to affect the coated product, yet strong enough to withstand the various other compounds with which it may come in contact such as perfumes, alcohols, soaps, and detergents. While many of the solvents incorporated into lacquers are strong enough to cause damage, the cooling effect of the spray process inhibits their action. Dispersants and wetting agents used to color plastics are troublemakers from the painter's point of view and best results are obtained from clear plastics. High impact polystyrene offers the biggest headaches since no two types are alike and crazing results from the use of conventional lacquer films. Invariably the coating must be spot formulated to achieve best results. Mold release agents also present difficulties and, when used excessively the item must be cleaned before painting. Silicone type release agents render effective coating impossible because the large amounts of alcohol incorporated into the lacquer tend to crawl away from the silicone, and as yet no economical method has been devised by which it can be removed from polystyrene products prior to decorating.

Addressing the meeting on thermoforming procedures, Louis H. Pfohl, Plaxall, Inc., traced the early history and development of the various processes and recommended that the word "thermoforming" be used as a general term when referring to all methods including pressure, vacuum, tool post, matched dies, etc. He stated that precision thermoforming will find extensive applications in the packaging industry, particularly for unit portions and disposable items, and that it will be used for many industrial and building products. Thermoforming machines, of the Design Center, Inc. type, now in operation at Plaxall and other licensed companies, have a total capacity of 200-million square inches of formed products per week. Within the next five years the industry is expected to quadruple its present $25-million annual sales, and by 1967 should reach $250-million.

The reinforced plastics sub-group was addressed by William J. Eakins, DeBell & Richardson, Inc., who spoke on "Standardized Test Methods for Reinforced Plastics." Mr. Eakins pointed out that the many variables inherent in the materials and processes which go into the manufacture of reinforced plastics have made it difficult to achieve a consistent product quality. In order to overcome this deficiency, it is necessary to formulate fundamental standards and test procedures against which all raw materials, pertinent to the process, can be compared.

New York

Packaging Program

A "Symposium on Packaging" was the central theme of the October 16 SPE meeting held at the Governor Clinton Hotel, New York, N. Y. A guest speaker, Mr. B. D. Garware of India, spoke on the progress of the industry in that country.

Howard L. Burpo, Jr., elaborated on the skin packaging method of applying a transparent plastic film over a product, permitting it to be attractively displayed and protected from damage. The article to be packaged is placed on a perforated backing sheet and the entire assembly acts as a mold. When vacuum is applied, air is evacuated through the holes in the backing and the plastic film is drawn tight over the article. Vinyl, cellulose acetate, and cellulose acetate-butyrate films are among the materials in current use. Once the type film and backing board have been selected, packaging reduces to a five-step vacuum forming operation including: loading of the forming unit; preheating the film; forming the film over the product; postheating, to activate the adhesive; and cooling and removal of the package.

Visualizing a bright "Future for Plastics in Packaging," Donald E. Westcott, W. R. Grace & Co., outlined the evolution of "technical packaging" with special emphasis on food handling. Using the Cryovac process as an illustration of current methods, Dr. Westcott explained that the material is an oriented saran-base film, that is stable at room temperature, shrinks uniformly, and has low moisture vapor transmission, and low oxygen permeability. Food is inserted into a loose fitting Cryovac bag; air is removed and the bag is sealed by twisting the neck into a tight cord which is secured by an aluminum clip. A momentary dip into hot water causes some of the polymer crystals to melt, allowing the molecules to pull back. In this manner, the bag is shrunk both longitudianlly and transversely by as much as 30-60%. The wrinkles are removed to make the film cling to the contours of the product like a second skin.

Some of the advantages cited for this method are: extension of storage life due to decreased bacterial growth; reduction of fat rancidation; and elimination of mold, freezer burn, and discoloration due to light. Other materials used in food packaging include Mylar, Du Pont's polyester film, and aluminum foil or cellophane laminated with various plastic films.

West New England

New Materials Night

C. Judd Holt, Jr.

Sixty-three members and guests braved the heaviest snowfall of the season to attend "New Materials Night" on January 8, at Betty's Towne House, Agawam, Mass.

Speakers were James A. Melchore, currently handling the Cymacs in the marketing section of the Plastics and Resins Division of American Cyanamid Company; Jack B. Spencer, technical service representative for Rohm & Haas Company; and R. J. Thompson, a sales development specialist in the chemical development department of General Electric Company.

Paul Stahlberg (Monsanto Chemical Company) was technical chairman.

Melchore described his company's new molding materials, Cymac 400 polymethylstyrene and Cymac 201, polymethylstyrene - acrylonitrile copolymer, both of which are available for evaluation. Pointing out that both products perform better at high temperatures than conventional styrenes, he exhibited a radio cabinet which was distortion free after 30 minutes at 212°F. He also said that the Cymacs have good low-loss electronic insulation properties which are retained after severe outdoor exposure. Both materials can be dry colored by conventional methods, he added.

Four high-impact methacrylate molding and extrusion materials were discussed by Spencer. They are: Implex A, with an Izod impact value of 2 ft-lb per inch of notched specimen; Implex B, with better gloss than Implex A and molding properties comparable to those of conventional Plexiglas; Implex 706 XP, specially formulated for piano keys and having Plexiglas's good light stability, stain resistance and machining properties; and Implex 708 XP, with Izod impact value equal to that of Implex B (0.8 ft-lb) but with a heat distortion temperature of greater than 200°F.

Lexan, a polycarbonate molding compound which "bridges the gap" in terms of heat resistance between thermoplastic and thermosetting materials, was described by Thompson. Introductory price of the new material, Thompson said, is $2.50 per lb, which will decrease to $1-1.50 per lb by 1960 when full-scale production facilities go on stream. Thompson said the material has excellent dimensional stability, an Izod impact value of 12-16 ft-lb, a heat distortion temperature of 280-290°F and a tensile strength of 8000-9000 psi. A full range of colors will be available, Thompson said.

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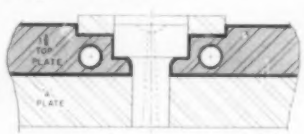

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2502

New Surface Coatings . .

(Continued from page 43)

Another outstanding characteristic of these coatings is their chemical resistance as illustrated in Table III.

Table III
Chemical Resistance of Diisocyanate–Castor Oil Clear Coatings

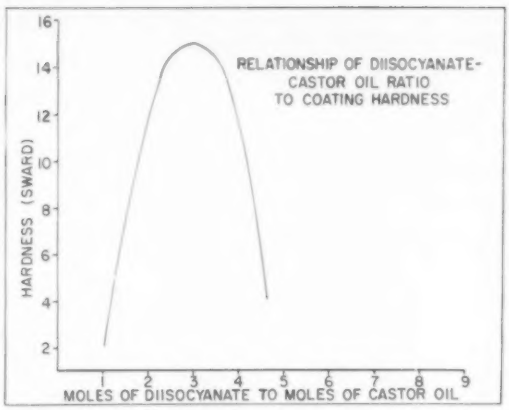
	TDI-Castor Oil (on steel)	MDI-Castor Oil (on steel)
Chemical Resistance:		
Boiling water	Good	Good
25% H_2SO_4	Excellent	Excellent
5% NaOH	Excellent	Excellent
5% Sodium Hypochlorite	Good	Good
Nacconol SL	Excellent	Excellent
1% Citric Acid	Excellent	Excellent
Mineral Spirits	Excellent	Excellent

It is possible to pigment these isocyanate-castor oil vehicles. Properties of film obtained from such pigmented coatings are as follows:

Table IV
Properties of Pigmented (TiO_2) Diisocyanate Castor Oil Coatings

	TDI-Castor Oil	MDI-Castor Oil
Abrasion Resistance (Taber Index)	22	20
Chemical Resistance		
5% NaOH	Excellent	Excellent
50% H_2SO_4	Excellent	Excellent

Figure 2.



Results such as these suggest a number of maintenance applications for the diisocyanate-castor oil coating. The results of a number of tests underway in our plants as well as outside, serve to illustrate what can be done.

Polyester-fiberglass drier pans are used in the chemical plant to dry various substances of different degrees of acidity, alkalinity and salt content. However, they often become severely corroded after relatively short periods of use. Essentially complete protection is obtained by the use of the MDI-castor oil coating.

Wooden plate and frame filter presses are another headache to the maintenance engineers. A coating made from MDI and castor oil had a service life against cold mineral acids more than double that obtained from the

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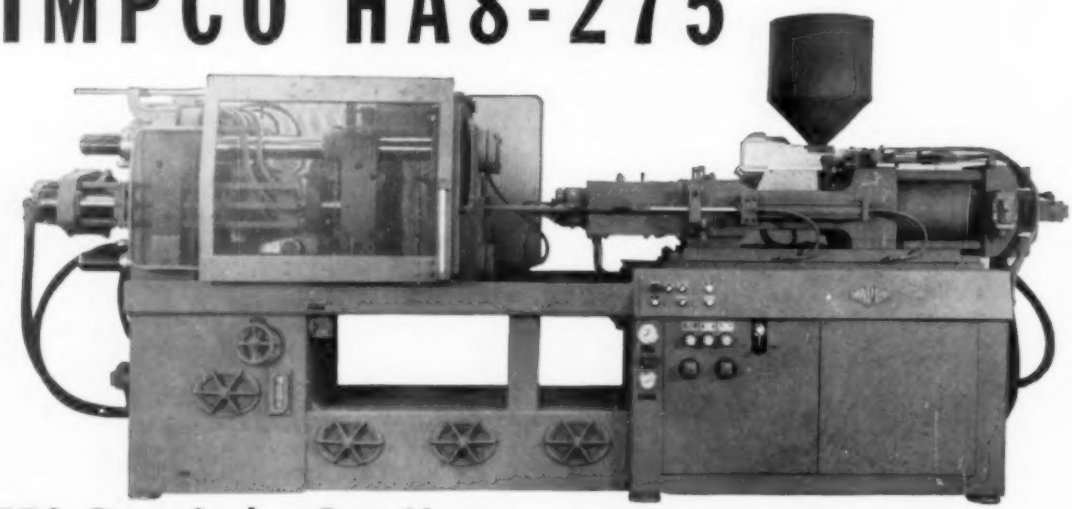

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coatings used previously. Considerably improved life of the press in service against 5% NaOH at 180°F. has also been obtained with this coating.

In the manufacture of cement blocks, the blocks, after molding, are cured in a steam chamber at 170-180°F., on steel racks. The replacement rate of the steel racks is normally very high, sometimes at the rate of five times per year. A set of racks coated with the MDI-castor oil coating has shown no corrosion after six months of service in this steam environment.

Concrete floors often develop cracks. This became quite a problem in a Buffalo business establishment where the second floor was used for a garage. Snow and ice would melt off the cars, dissolve road salt and run through cracks in a ramp onto material stored on the lower level. An MDI/castor oil coating brushed into the cracks solved the problem. After six months there have been no complaints and the coating has withstood the traffic without significant wear. It also shows promise as a durable moisture barrier for use on concrete block.

The castor oil-diisocyanate coating is a reasonably inexpensive vehicle for applications requiring resistance to chemicals. Methods of handling are only very slightly different from coatings presently used in this field. ★ ★

Heat Blast Effects . . .

(Continued from page 40)

cracking of the surface layers of asbestos. (Figures 11 and 12)

None of the coating materials inhibited damage sustained by the laminates to any appreciable extent.

Conclusions

These tests show:

1) Reinforced plastic laminates possess a relatively low thermal conductivity. During short time, high-temperature exposure, the temperature in the interior of the plastic laminate will be considerably lower than the surface temperature. Damage in the form of glass fusion, resin charring, and erosion will, therefore, be largely confined to the surface of the laminates during exposures up to 18 seconds, but will progress toward the interior of the material with increasing exposure time.
2) Phenolic laminates containing either glass or asbestos reinforcement retain a fair degree of structural integrity after exposure to 3000°F, for periods up to 60 seconds. The asbestos-phenolic material exhibited a higher strength, but a lower thermal shock resistance than the glass-phenolic laminate.
3) In the asbestos-phenolic specimens, the outer layer of asbestos remains in place even after the complete deterioration of the surface resin. This provides a protective layer which tends to insulate the inner material and slows down the rate of decomposition of the material.
4) The silicone laminates are more stable in a high-temperature environment than any other plastic material. Silicones, however, have inherently poor strength characteristics and soften appreciably at high temperatures.
5) Glass fabric-polyester laminates were found to be unsuitable for short time, high-temperature applications.
6) Coatings applied to protect the surface of the laminates were ineffective, since none of the coatings was able to withstand the exposure for any appreciable time. ★ ★

PRODUCT-DESIGN
MEMOS
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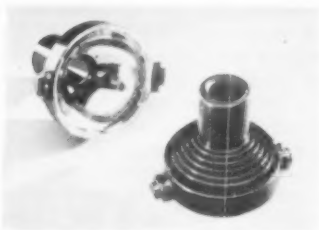


Metallized phenolic does job of mirror

To sidestep the cost of a custom-made mirror for this microscope lamp housing, the housing is molded of Durez phenolic. Then a bright aluminum reflector is deposited on the plastic by vacuum evaporation. *For description of Durez molding compounds for jobs like this, write for descriptive four-page bulletin.*

Phenolic gear outwears metal, costs 2/3 less

This automotive oil-pump gear outwears metal gears nearly 3 to 1; withstands heat, oil, and acids; runs more quietly than metal gears; and saves about two-thirds the cost. It's made with Durez 16771, a new high-impact glass-filled phenolic. *For information on this high-strength compound, write for technical data sheet.*

New hardener makes epoxies fire-retardant

You can now make epoxy laminates that hold their flexural strength in the 300-350° F range and won't support flame. In flame test shown here, laminate cured with HET Anhydride, a Durez hardener, snuffs itself out while conventional laminate ignites in 30 seconds, burns completely in about three minutes. *Write for technical data on HET Anhydride.*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
1102 Walck Road, North Tonawanda, N. Y.

Conical Heat Chambers . . .

(Continued from page 29)

tioned in each chamber. With the conical chamber, assuming equal heat available in all sections from the source, the ram end has a higher watt density because the heating area is small. As the material is warmed, the area is increased, decreasing the watt density. This tends to ease the chance of plastic decomposition due to too high a watt density when the plastic is hot. This and the mulling action tend to create a very even stock temperature.

Refer again to Figure 2. Just as any decreases in area tend to speed up the plastic, due to more pressure used, any increase in area tend to slow the plastic down. Note a very rapid increase in area around the eleven inch mark on the replaced chamber. This is the area where most decomposition seems to start. This is probably due to the plastic being fairly warm and to a rapid loss of pressure. The lack of any rapid increases in area for the conical chamber, along with the smooth blending of all surfaces, minimize the possibility of any decomposition under normal operating conditions. Because of these two points and the mulling action, the conical chamber tends to be self cleaning. At the end of a six month production run, twenty four hours a day, five or six days a week, the chamber was taken apart and inspected. Both polystyrene and rigid polyvinyl chloride had been run. There was no indication of wear, pitting, or charring. The chamber didn't even have to be polished.

Ease of Assembly

To dismantle and reassemble the conical chamber is comparatively easy. The torpedo is held in place with twelve nuts on studs. If one should freeze, it is easier to deal with than a frozen bolt. The nuts are removed and a light nudge is given with the injection ram. The torpedo, plastic and all, comes out due to the tapered wall of the shell cavity. To remove the plastic one just cuts or chips it away from the torpedo, as most of it is exposed. To reassemble, merely slip the torpedo in place and tighten the nuts.

Here, in the table at the left, are the results of the first heat chamber compared with the replaced chamber.

As in all fields where there are problems, the answers are somewhere. I hope the conical heat chamber will aid the plastic field. It has some advantages over other chambers but is certainly not the perfect chamber. Maybe someone in the near future will develop that chamber. ★★

Comparison of Results—Standard vs. Conical Chambers

	Rigid Polyvinyl Chloride		Polystyrene	
Item	Replaced Production	Conical Production	Replaced Production	Conical Production
Zone 1	300°F	320°F	430°	450°F
Zone 2	310°F	300°F	470°F	440°F
Zone 3	——	300°F	——	440°F
Nozzle	280°F	300°F	430°F	440°F
Torpedo	——	300°F	——	440°F
Clamp	37 sec	26 sec	37 sec	26 sec
1st Shot	11 sec	10½ sec	12 sec	11⅛ sec
2nd Shot	4 sec	2¼ sec	3½ sec	2 sec
Line Pressure	2600 psi	2550 psi	2200 psi	1800 psi
Ram Diameter	2"	2½"	2"	2½"
Ram Pressure	31,850 psi	20,012 psi	26,950 psi	14,112 psi
Core Temperature	90°F	85°F	105°F	90°F
Cavity Temperature	160°F	150°F	172°F	158°F
Blemishes	yes	no	yes	no

BIBLIOGRAPHY

(1) Uniformity Considerations For Plastic Stock Temperatures In Injection Molding
A. L. Baird & Joe Eveland
SPE Technical Papers — Vol. 3
Pages 180-190

Oil Field Pipe . . .

(Continued from page 52)

cess of plastic in controlling corrosion or paraffin, four operators voluntarily indicated plastic was not satisfactory for paraffin control.

Reasons for Not Using Plastic Pipe

The questionnaire also sought to determine why non-users or small users did not use extruded plastic pipe. Table 14 is a composite of these replies. Here again many operators reported duplicate reasons; others reported none.

Information Wanted by Small Users

This portion of the questionnaire was designed to determine what information small users or non-users would like in their consideration of extruded plastic pipe. A composite summary of the replies is shown in Table 15. The preponderance of operators desire data on strength characteristics backed up by operating experience, plus information on installation costs. The latter may be answered to some degree by the information presented in this report.

The five operators desiring other information were interested in (1) the technique of making road crossings for lines laid above ground, (2) paraffin control experience, (3) the best method for threading and coupling, (4) data on thermal expansion, and (5) impact strength. ★ ★

Necrology

Richard West

Richard West, President of West Instrument Co., and long-time member of Chicago section of SPE was killed December 1957 when his private airplane crashed into Lake Erie. He was on a business trip from Rochester to Detroit when both motors of the plane stopped.

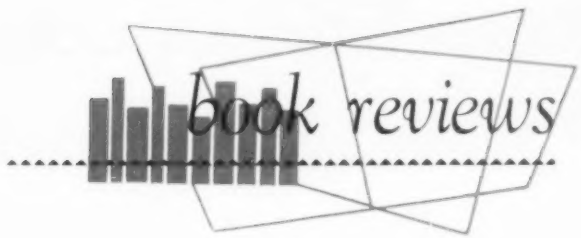
Plastics Around the World . . .

(Continued from page 63)

ing in solvents, migratory bleeding, and efflorescence. The phenomena are described and discussed. Some means are presented for their possible elimination. (Illustrated)

Mazzucchelli Celluloide Professional Training Center

In an attempt to meet a critical failing of Italian labor, that is, lack of training and qualifications, the firm of Mazzucchelli Celluloide has inaugurated a school for professional training. The studies range from qualification courses in specific areas of short duration, to more general courses of longer and more complex character leading to eventual supervisory and creative factory positions. The courses are open to qualified graduates of all Italian elementary schools.



Handbook of Radiochemical Analysis, distributed by OTS in the interest of Industry. US Department of Commerce, Washington, D.C., 1953, Reports PB 121 689 and 121 690, 2 volumes, offset, paper bound, letter size, 273 pp., $7.25.

These reports, just published, are reprints of original documents describing research work done in 1952 and 1953 under the technical direction of L. R. Zumwalt and released to the public for the first time. In volume I, the reader finds Section One dealing with laboratory techniques and instrumentation, specifications for various tagged chemicals and counting instructions. Section Two contains statistical curves for the above chemicals. Volume II is devoted to chemical procedures, analyses of tagged metals decontamination and determination procedures.

Remembering our pioneering work with radioisotopes 9 years ago, and the numerous periods of trials and errors, we can only recommend warmly the perusal of these two books. They are easy to read and contain all the information one may desire on this fascinating field of modern chemistry.

Louis C. Barail

Handbook of Chemical Data, Edited by F. W. Atack. Reinhold Publishing Corporation, New York, N.Y., 1957, pocket size, 629 pp., $6.75.

It is not easy to condensate in a small pocket size book the essential data usually found in much larger and also more expensive year books or reference manuals, and to select for the benefit of the reader what should be put in and what could be left out.

It seems to us that this has been achieved here, quite satisfactorily. You will find physico-chemical constants, solubilities, inorganic and organic compounds, qualitative and volumetric analyses, and many fundamental data anyone in the chemical field likes to find at his finger tips. We recommend that you put this handy and inexpensive book on your next shopping list.

Louis C. Barail

Chemical Engineering Cost Estimation
by Robert A. Aries & Robert D. Newton
263 pp. McGraw Hill, New York, 1955, $6.00

The purpose of this book is to help manufacturers and capital investors in determining manufacturing costs so they can ascertain the feasibility of marketing a new product or improve on the manufacturing processes already in use in their plants.

It is divided into 10 chapters dealing with capital investment, plant cost in equipment and other expenses, manufacturing, overhead, sales and profits, variable conditions, components of cost and economic evaluation. It contains many charts and numerous tables giving costs per unit of buildings, utilities, chemicals, power, labor and maintenance.

This little book will serve as a good base for individual manufacturing costs studies.

Louis C. Barail

Handbook of Toxicology, Volume II: Antibiotics
Edited by William S. Spector. 1957, 264 pp., $6.00 (W. B. Saunders Company, Philadelphia, Pa.)

The first volume of this series, which we reviewed for the SPE Journal in 1956 became a success very fast. The second volume will be read, not only by toxicologists and other medical or chemical people, but by laymen as well.

It gives the toxicological data, acute and chronic, of 340 antibiotics. As many sufferers of colds, Asian flu or more or less serious infections have been or are given antibiotics, "the miracle drugs", many patients so treated will certainly like to know more about the relative toxicity of these excellent remedies. Besides toxicological data, this book gives the source, chemical and biological properties, reactions and mode of action of most of these powerful therapeutic agents.

A very up to date bibliography contained in close to 40 pages lists all possible references in the American and Foreign medical and chemical literature. Furthermore, the appendix gives cross references of all antibiotics and their individual mentions in the various parts of the book.

An opus of the highest scientific value.

Louis C. Barail

The Elements of Physics
By Alpheus W. Smith and John N. Cooper, Sixth Edition, 1957, 671 pp., $7.50 (McGraw Hill Book Co., Inc., New York, N. Y.)

The success of the first editions of this textbook prompted the publishing of this 6th edition. Although it is written for students, more advanced readers will enjoy it for several reasons: 1) the field of physics is too wide to be fully familiar to specialized technicians (plastic engineers, for example); 2) new developments in modern physics will be found here close to better known data; 3) to many of us, the relations of the British system, the mks and cgs metric systems are still a little obscure. The book is a great help in this matter; 4) the numerous figures, diagrams and illustrations in color and black and white, charts and table will be consulted very often.

This manual is divided into seven parts, an appendix and an index: mechanics, wave motion and sound, heat, light, electricity, atomic and nuclear physics and electronics. All chapters are up to date, simply written and end with problems the solving of which helps the comprehension of the text. Many of you will want to have this manual on your desk.

Louis C. Barail

Source Book of Industrial Solvents, Vol. 2, Halogenated Hydrocarbons
by Ibert Mellan (Reinhold Publishing Corporation, New York, N. Y.)

This book is a valuable reference for the chemist, engineer, or formulator engaged in work with paints, plastics, adhesives, coatings or solvents. The common industrial halogenated solvents have been classified as to physical properties and solvent characteristics and grouped according to distillation range for ease of location. A historical coverage is given each group of solvents with the treatment of the fluorinated hydrocarbons meriting special mention. The detailed description of each common solvent is specific and can be found in no other single source.

There is a format error in the description of methylene chlorobromide on page 224.

W. R. Lawton

CLASSIFIED ADS

Positions Wanted

Materials Engineer—Plastics Chemist: M. S. Practical know-how; 15 years broad supervisory experience: R & D; applications, consulting, technical service. Thermosetting molding compounds; high-temperature structural and electrical laminates; adhesives; binders; paper; fiber-pulp-resin combinations. Interested only in major position. Reply Box 1058, SPE JOURNAL, 34 East Putnam Avenue, Greenwich, Connecticut.

Plant Manager

Background of Industrial and Mechanical Engineering. Experienced in manufacture of plastics and metal products. Capable of developing and maintaining a profitable operation. Coordination of manufacturing, engineering and sales. Age 39. Will relocate. Presently employed. Box 2857, SPE Journal, 34 East Putnam Avenue, Greenwich, Conn.

Plant Manager—Tool Supt.

Engineer - Age 50 - Heavy experience in thermosetting plastics molding and finishing including automatic methods. Broad thermoplastic experience with styrene, acrylics, acetates, nylon, etc. Presently Mfg. Eng. Supv. with leading plastic molding company. Available in 30 days. Seek position as Plant Manager or Tool Superintendent. Prefer captive molder. Reply Box 958, SPE Journal, 34 East Putnam Ave, Greenwich, Connecticut.

CHEMICAL ENGINEER - Manager

11 years experience - process development work, polymerization, compounding, coloring, extrusion and injection molding. Have been responsible for plant layout, organization, material handling, maintenance, mold construction and plant operation. Reply to Box 758, SPE Journal, 34 East Putnam Avenue, Greenwich, Connecticut.

Engineer

PLASTICS ENGINEER: Over nine years diversified experience in plastics. Three years of studies in laboratory scales about phenolic plastics (resols, novolacs, moulding compounds, cast phenolics, etc.) and six years as supervisor in the production of phenolic plastics, resins and varnishes, impregnation of paper and cloth, pressing with molding compounds, industrial and decorative laminated, elaboration of phenolic moulding compounds, and finishing of moulded articles. Initiated in vacuum forming and in the elaboration of sheets of polystyrene by extrusion for vacuum forming. Familiarity with the development of plastic products. Chemical Engineer (University) from 1949. Technical and personal references gladly furnished. Reply Box 858 SPE Journal, 34 East Putnam Avenue, Greenwich, Connecticut.

WANTED

Sales representative wanted for Eastern U.S. to handle the sales of vinyl plastisols, organosols and solution coatings. Technical background required as well as selling experience. Address replies to Auburn Plastics, Inc., Chemical Processing Division, Auburn, New York.

Process Engineer Wanted

Capac Industries, Inc., of Capac, Michigan, producers of extruder, vacuum formed, compression molded products and industrial laminated sheet stock, is looking for a process engineer. Send your resume to Arnold M. Varner, Plant Superintendent.

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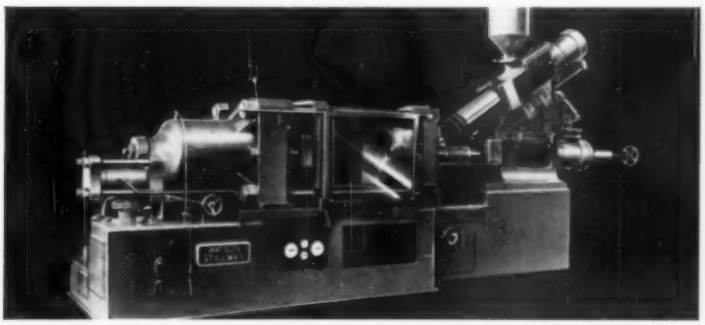
These and many other features of the PE-64 are described fully in bulletin 624. Write for your FREE copy today. Information also available on vertical injection machines, compression and transfer molding presses.



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